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SUGARBEET RESEARCH

1964 REPORT

Compiled by Sugarbeet Investigations

CROPS RESEARCH DIVISION
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Crops Research Division
Beltsville, Maryland

SUGARBEET RESEARCH is an annual compilation of research accomplishments by staff members of Sugarbeet Investigations and Cooperators.

The Report is a medium for presenting results of investigations strengthened by contributions from the Beet Sugar Development

SUGARBEET RESEARCH

Foundation and for reporting research accomplishments under Cooperative Agreements between

1964 REPORT^{1/}

the Division, Agricultural Research Service, U.S. Department of Agriculture, and the Beet Sugar Development Foundation, the Farmers & Manufacturers Beet Sugar Association, and White Sugar Refining, Consolidated Foods Corporation.

At Salinas, California, research has been strengthened through contributions from the Farmers Beet Growers Association, Ltd.

Foundation. Compiled by Sugarbeet Investigations. It is not meant that all investigations included in that portion of the Report received support from the Foundation.

Trade names given in this report to provide specific information and do not signify recommendation by the U.S. Department of Agriculture.

^{1/} This is a progress report of cooperative investigations, containing data, the interpretation of which may be modified with additional experimentation. Therefore, publication, display, or distribution of any data or statements herein should not be made without prior written approval of the Crops Research Division, ARS, U.S. Department of Agriculture, and the Cooperating Agency or Agencies concerned.

FOREWORD

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At Salinas, California, research has been strengthened through contributions from the California Beet Growers Association, Ltd.

Foundation project numbers on "Part" title pages do not mean that all investigations included in that portion of the Report received support from the Foundation.

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HIGHLIGHTS OF RESEARCH ACCOMPLISHMENTS

A. Genetics and Breeding

New Items of Breeding Material.--In 1964, 25 items of breeding material developed by the staff of Sugarbeet Investigations were proposed for seed increase and utilization through the Beet Sugar Development Foundation. Some were appraised in breeding programs of cooperators; others were selected for seed increase by the winter-annual method. Description and suggested utilization of the various items are given on pages 7-16. The 1964 seed productions of 1963 items are given on page 17.

America's Sugarbeet is Monogerm.--The dramatic development of monogerm varieties suitable for most districts in North America is an outstanding accomplishment in the history of the sugarbeet, achieved through research conducted by Sugarbeet Investigations, sugar companies, and the beet seed enterprise. The summary table (p. 18) from AGRICULTURAL STATISTICS shows that during the triennium 1962-1964 monogerm varieties and hybrids comprised about 88 percent of our sugarbeet seed production. Seed of monogerm varieties is used exclusively in most districts, which results in a significant reduction in labor requirements for thinning and weeding.

US H7 and US H8.--In 1964, two commercial monogerm hybrids, US H7 and US H8, were released. These 3-way hybrids were developed in the breeding research of J. S. McFarlane and associates (p. 20). The seed parent in both hybrids is C562 X C569, a monogerm male-sterile F_1 . Complementary monogerm pollinators (C663 for US H7 and NB7 for US H8) are employed to impart distinguishing characteristics. US H8 has more resistance to curly top than US H7, and in some tests in California it has been outstanding in bolting resistance.

Triploid Hybrids.--Triploids US H6 and US H7 were produced by employing tetraploid pollinator C663. Field tests were conducted by McFarlane et al. (p. 20), during 1963 and 1964, to compare the diploid and triploid hybrids. The root yield of the triploid was higher than that of the equivalent diploid; contrariwise, the sucrose percentage was lower. Resistance to curly top and virus yellows was similar for both ploidy levels. The triploid tended to be more resistant to bolting. McFarlane et al. (p. 21) and Helen Savitsky et al. (p. 280) report poor seed germination as a depreciating characteristic of triploid hybrids.

Haploid Sugarbeet.--Haploid plants of sugarbeet are of interest as precursors of autodiploids that enable the geneticist to achieve, in one step, a degree of homozygosity that would be difficult to approach in decades of conventional inbreeding. The haploid plant discovered by B. L. Hammond (p. 64) was diploidized by colchicine treatment, and a fertile homozygous line has been established that will be useful in experiments where genetic variability is objectionable.

Interspecific Hybridizations.--Helen Savitsky (p.276) reported significant progress in transferring germ plasm from viny species of Beta (Patellares Section) to the sugarbeet (Beta vulgaris). Cytogenetic studies on Vulgares-Patellares F₁'s established that chromosomes originating from parental species tend to associate but that the sugarbeet chromosomes do not pair exclusively among themselves. Thus chromosome interchange and segmental exchange may occur in gamete formation. In the backcross, the transfer of chromatin material is expressed in unique growth and development, such as annualism and tumors, as well as in resistance to the nematode.

Nematode Resistance.--The viny species of Beta (B. procumbens, B. patellaris, and B. webbiana) are the only forms of beet immune to the cyst nematode (Heterodera schachtii). Backcross populations developed in the genetic research of Helen Savitsky (p.278) were evaluated in the greenhouse. From the several tests, 47 plants (about 7%) were free of nematode cysts or had only 2 to 6 cysts on the root systems--an important accomplishment which represents a breakthrough in a difficult research assignment. Seed has been produced from these nematode-resistant segregants and research is continuing.

Genetic tumors have intrinsic value in cytogenetic studies of interspecific hybrids of Beta. Helen Savitsky (p.276) examined 17 b₁ plants with tumors and found 6 with 18 chromosomes, 6 with 19, 3 with 20, 1 with 21, and 1 with 29. The plants with 18 chromosomes, the diploid number for sugarbeet, are considered as having received segmental exchange rather than interchange of entire chromosomes from the wild parental species. Genetic tumors occur in interspecific hybrids of Nicotiana (Tobacco). Of the 55 or more species of Nicotiana, according to information supplied by Tobacco Investigations only those with 9 chromosomes induce tumors in interspecific hybrids. Cytological research has indicated that probably only 1 of these 9 chromosomes is responsible for tumor formation. This provides a conspicuous marker for a cytological entity that would otherwise be difficult to identify.

Pollen Sterility.--Maternal inheritance of pollen sterility in the sugarbeet is the biological mechanism employed in the commercial production of hybrid seed. According to postulates of F. V. Owen, matrocliny for pollen sterility in the sugarbeet is conditioned by the interaction of cytoplasmic and Mendelian factors. Frequently the transmission of pollen sterility in breeding material does not conform to that expected from the postulates. J. C. Theurer and E. H. Ottley (p. 68) investigated the possibility that pollen sterility is caused by a virus transmitted from mother plant to its seed. They were unable to show (except for one questionable example) that entities conditioning pollen sterility pass through graft unions that are readily traversed by the curly top virus. The unsuccessful efforts of J. C. Theurer and G. K. Ryser (p. 81) to stabilize a line that will completely restore pollen production in progeny of matroclinal male-sterile plants has a bearing on the mechanism of pollen sterility in the sugarbeet. Mendelian (aa) sterility is under study by J. C. Theurer and C. H. Smith (p. 77).

Breeding Procedures.--LeRoy Powers and R. J. Hecker (p.199) established for the breeding material in their experiment that the greatest increase in root weight per plant, attributable to selection, was 16 percent, whereas that due to association of root size with color of root and hypocotyl was 49 percent. This indicates the value that could be attached to knowledge of chromosome mapping and genetic linkage of marker characters in the sugarbeet. Their research on a phenolic compound of the sugarbeet in relation to resistance to Cercospora beticola did not permit a firm conclusion, because environment greatly influenced the concentration of the chemical.

B. Variety and Quality Evaluation

Variety Evaluations in the Great Lakes Region.--G. J. Hogaboam and associates (p.114) conducted extensive field trials with major assistance from the Farmers and Manufacturers Beet Sugar Association. The performance of monogerm hybrids generally used in the region was satisfactory, but the tests revealed that in root yield the experimental 3-way hybrid (SP 6121 X EL61G)ms X SP 5822-0 was best. Statistical analysis of the data show that much improvement in acreable yield of sugarbeet can be achieved by proper agronomic practices.

Regional Tests of LSR-CTR Varieties.--J. O. Gaskill and cooperators conducted 20 regional field tests to evaluate varieties for leaf spot and curly top resistance and hybrids for resistance to both diseases (p.166). In tests at Fort Collins, Colorado, and Beltsville, Maryland, where leaf spot occurred in epidemic proportions, the sugarbeet hybrids and varieties with a high level of resistance to Cercospora beticola performed best; similarly, only the resistant entries gave satisfactory yield in the tests where curly top exposure was severe (photo, p.167). Acceptable tolerance to both pathogens was not attained for a variety. A topcross test revealed the excellent performance of hybrids involving monogerm lines FC 502, FC 502/2, FC 503, and FC 503/2.

Experimental Hybrids and Breeder Seed.--Field tests by G. J. Hogaboam and D. L. Mumford in Michigan and Ohio (p.136), by J. O. Gaskill at Fort Collins, Colorado (p.157), and by G. E. Coe at Beltsville, Maryland (p.379), permit regional appraisal of new breeding lines and experimental hybrids of sugarbeet. These tests show the excellent quality of SP 5822-0 as a pollinator. Hybrids involving monogerm FC 502/2 were best in recoverable sugar. FC 503 and relatives were also excellent parental material. The tests conducted by Northern Ohio Sugar Company (p. 151) reveal the excellent thin juice purity of SP 6322-0, which has had two generations of selection from SP 5822-0.

Seed Quality and Triploidy.--Low germination of seed is a deterrent to use of monogerm triploid varieties of sugarbeet. Helen Savitsky and others (p.280) studied seed formation and quality as influenced by the pollinator. The male-sterile monogerm diploid C569-H3 served as the female parent, but in each of three seed fields a different pollinator was used--namely, a diploid monogerm, a diploid multigerm, and a tetraploid multigerm. Five plants of the male-sterile seed parent from each field were studied intensely in relation to ovule fertilization and development of embryo. The percentage of fertilized ovules in flowers of the male-sterile monogerm was about 86% and did not differ significantly for the fields or the pollinators. In contrast, embryo development was not equally successful after fertilization by each of the pollinators. The highest incidence of embryo abortion occurred with the tetraploid pollinator. The diploid seed germinated 84% and 87% for monogerm and multigerm pollinators, respectively, and for the triploid seed, 50.7%. Fertilization and the ontogeny of triploid embryos need further study.

Seed Quality and Maturity.--The importance of scheduling harvest of sugarbeet seed at optimum maturity is emphasized in the experiments of I. O. Skoyen (p. 57) and F. W. Snyder (p. 371). Harvest of immature seed results in poor germination and unthrifty seedlings. It is difficult to establish optimum stage of maturity for the sugarbeet, because its growth is indeterminate and its populations are composed of plants varying in vigor. Effective processing is required to obtain maximum seed quality. The blotting paper method of seed germination was not as reliable as the sand method.

Measurement of Quality.--The downward trend in sucrose percentage in sugarbeet roots and in purity of juice emphasizes the need for a precise method of measuring quality. Myron Stout (p. 89) has developed a simple procedure that is thought to be reliable. In this Report, extensive use has been made of thin juice purity and clear juice purity in evaluating the outcome of breeding research (pp.114, 155, and 237). The competence of the investigators and the extent of interest give promise of a precise test for recoverable sugar that will be generally acceptable for routine laboratory procedures.

C. Diseases and Their Control

Virus Yellows Resistance.--Although yellowing of leaves is symptomatic of virus yellows of sugarbeet, reduction in root yield is the most reliable measure of damage induced by the disease. If conditions are unfavorable for the major aphid vector (Myzus persicae)--such as in May plantings at Davis, California--companion plots of infected plants and virus-free plants of the same population can be maintained until harvest. In such tests, the reduction in root weight, induced by viruses, can be reliably determined. J. S. McFarlane, C. W. Bennett, I. O. Skoyen, and R. J. Hecker (p. 301) appraised the relative tolerance of several items of breeding material. Beet yellows and beet western yellows combined caused reductions ranging from 13.9 to 41.7 percent in root weight and from 1.1 to 1.7 percentage units in sucrose. The investigators determined that selecting for tolerance was effective.

Chemical Test and Yellows Resistance.--Investigations by J. M. Fife (p.308) established a relationship between virus yellows infection and a pattern of amino acid concentrations in sugarbeet leaves. Improvement in breeding material has been demonstrated through the use of yellowing of leaves and amino acid pattern as selection criteria (photo, p. 316). The most significant gain from these selections has been in sucrose percentage.

Beet Yellows and Western Yellows Viruses.--C. W. Bennett (p.317) summarized a 4-year study on strains of yellows viruses of sugarbeet in the United States. The entity known as beet yellows virus causes more damage than the beet western yellows virus. Since some strains of the beet yellows virus are mild, the study concerned the probability that they actually cause beet western yellows. Major differences between beet yellows virus and beet western yellows virus are their differential ability to induce disease symptoms in five species of plants and the retention of the viruses by the green peach aphid (*Myzus persicae*). The results of his investigations with beet western yellows virus and mild strains of the beet yellows virus strengthened the original concept that the two viruses are distinct species of the pathogenic agent.

Comparison of English and American Yellows.--In England, two strains of sugarbeet yellows have been identified; as in the United States, one is mild and the other severe. There is general agreement that beet yellows virus in U.S.A. is essentially the same as beet yellows virus in England. Bennett (p. 322) furnishes evidence that beet western yellows virus in U.S.A. and sugarbeet mild yellows virus in England are equal in pathogenicity. From his observations and experimental evidence, it is reasonably certain that sugarbeet mild yellows in East Anglia, England, is the same as beet western yellows in the United States.

Yellow Stunt Virus and Pseudo-Yellows Virus.--Investigations by J. E. Duffus (pp. 328 and 339) call attention to two new viruses that induce yellowing of sugarbeet leaves: 1) The pseudo-yellows virus, found in the greenhouse on weeds collected in the vicinity of Salinas, California, and 2) the yellow stunt virus, which occurs in the Salinas Valley on sowthistle. The pseudo-yellows virus may not be of economic significance, since its vector, the common whitefly, usually does not feed on the sugarbeet. The yellow stunt virus is transmitted by at least three species of aphids--including the green peach aphid, which is the major vector of sugarbeet yellows.

Curly Top Resistance Tests.--C. L. Schneider (p.98) and A. M. Murphy (p.106) evaluated items of breeding material to determine the concordance of curly top resistance ratings resulting from greenhouse inoculations with the symptoms manifest under field exposures. Plants of populations evaluated in the greenhouse were inoculated singly with a severe strain of the virus by confining viruliferous leafhoppers (*Circulifer tenellus*) to cotyledonal leaves. In field trials, feral leafhoppers were baited by an early planting

of a susceptible variety of sugarbeet and were provided with the curly top virus by intercalating infected plants of the previous year among the experimental plots. In 1964, the severity of damage by the virus in greenhouse tests and grades of curly top symptoms in field trials were significantly correlated for more than 100 items of breeding material.

Curly Top Strains.--Constant surveillance is required if we are to keep abreast with the insidious development of extremely virulent new strains of the curly top virus. C. W. Bennett (p. 325) reported the discovery of two new strains--one in cucumber received from Texas and the other in Chenopodium murale from the Imperial Valley of California. These strains are not presently a hazard to sugarbeet production but are of intrinsic interest in demonstrating the marked diversity in the curly top virus. C. L. Schneider (p. 94) purified and evaluated 37 isolates of the curly top virus collected in Utah and found differences in virulence on various suspects.

Cercospora Leaf Spot Control.--The apparent buildup in leaf spot intensity, availability of more effective fungicides, and development of efficient methods of application have stimulated interest in controlling the disease by direct measures. L. Calpouzos and G. F. Stallknecht (p. 348) demonstrated that ground spraying and helicopter spraying of fungicides are equally effective in reducing damage induced by a moderate epidemic of the disease. Increase in root yield of more than 2 tons per acre and improvement in sucrose percentage were attributed to the fungicidal treatments. For the 1964 tests, the gains from the treatments were considered economically advantageous.

Studies on Fungous Pathogens.--L. Calpouzos and G. F. Stallknecht (p. 360) found that light influenced the sporulation of Cercospora beticola and that a temperature of 22.5 C was most favorable. They point out that innate ability of the isolate to sporulate in culture is required for response to environmental and nutritional factors. D. L. Mumford (p. 365) describes a simple method of provisional identification of fungous pathogens of sugarbeet (photos, pp. 368 and 369). In the greenhouse, sugarbeet pathogens in soil samples revealed the general occurrence of Aphanomyces cochlioides and Pythium ultimum and a low incidence of Rhizoctonia solani. The latter pathogen was more frequently isolated from diseased seedlings collected in the field.

Rhizoctonia Resistance.--The development of tolerant lines of sugarbeet offers promise of reducing root rots caused by R. solani. The research of J. O. Gaskill (p. 341) has established an effective screening procedure for the selection of resistant genotypes. He applied the procedure to actual breeding experiments. Heritable variations in tolerance to the pathogen occurred in sugarbeet populations. Selecting for resistance resulted in measurable improvement.

Tetraploidy and Disease Resistance.--V. F. Savitsky, H. Savitsky, and A. M. Murphy reported progress in combining resistance to both leaf spot and curly top in tetraploid populations (p. 240). Tetraploidization of US 401, which is moderately resistant to leaf spot, resulted in improvement in curly top resistance. Selecting for leaf spot resistance in tetraploid US 401 showed no significant improvement but did result in some reduction in curly top resistance. Conversely, selecting for curly top resistance resulted in marked improvement, while the level of leaf spot resistance remained about the same as for diploid US 401. The best combination of resistance to leaf spot and curly top was obtained in F_4 tetraploid populations derived from hybridization of $4n$ US 401, moderately resistant to leaf spot, and $4n$ monogerm lines that are moderately resistant to curly top. Combining two desirable genomes from complementary autotetraploids into one population is proposed as a breeding method for the association of polygenic traits. V. F. Savitsky (p. 254) found selecting for bolting resistance highly effective in autotetraploid populations.

Summary of Accomplishments prepared by Dewey Stewart.

P A R T I

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase 1964
and
Utilization and Distribution of Items

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Seed Production of 1963 Items

PRODUCTION OF MONOGERM SEED IN U.S.A.

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase

May 26, 1964

Breeder seed, inbred lines, and hybrid varieties, which have been developed in the breeding research conducted by the staff of Sugarbeet Investigations, are proposed for seed increase through the Beet Sugar Development Foundation. Seed not needed for planting overwintering plots will be furnished on request to company members of the Foundation for utilization in their breeding programs. Brief descriptions, current designations, and estimates of seed available August 1 are given for the items.

These new products of breeding research have been developed by the staff of Sugarbeet Investigations in work conducted under Cooperative Agreements with:

Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
Minnesota Agricultural Experiment Station
Utah Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Association
Union Sugar Division, Consolidated Foods Corp.

Items Proposed for Seed Increase and Utilization

I. U.S. Agricultural Research Station, Salinas, California.

A. Developments in breeding research by J. S. McFarlane and associates, B. L. Hammond and I. O. Skoyen:

Item 1. C3534 Monogerm 1 pound

A curly-top-resistant, type O, monogerm inbred selected from a cross between NB1 and C2563 (Item 1 of 1962.) Greenhouse tests have shown C3534 to be equal or superior to C2563 in curly-top resistance. Bolting resistance is very good.

Suggested utilization: a) Use as a breeding line; b) may be increased for possible use as a curly-top-resistant monogerm inbred parent.

Item 2. C3534H4 Monogerm 1 pound

A male-sterile monogerm from a cross between 563HO and C3534.

Suggested utilization: a) Use as the seed-bearing parent in the production of the male-sterile equivalent of C3534, and b) produce an F_1 hybrid between C3535H4 and 546 (Item 12, 1961) or 550 (Item 1, 1963).

Item 3. C321 Multigerm 100 grams

A yellows-resistant selection from the type O, self-sterile line C671 which was made available in 1956. Tests at Davis, California, showed C321 to be superior in yellows resistance to the parent variety and to the U.S. commercial hybrid varieties. C321 has good resistance to bolting and curly top.

Suggested utilization: Use as a yellows-resistant breeding line. A seed increase is not recommended.

Item 4. C3539T Multigerm 1 pound

Increase of tetraploid from the NB7 inbred. Combines good bolting resistance with very good curly-top resistance.

Suggested utilization: Use as a tetraploid breeding line. Preliminary results indicate that C3539T is less vigorous than diploid NB7 and probably cannot be used as the pollen parent in commercial hybrids.

B. Developments in breeding for nematode resistance, by Charles Price:

Item 5. 101-7 Multigerm 1 pound

Four successive selections from US 33 for nematode resistance. The fourth selection was made from a large population of plants in the greenhouse for tolerance to combination of nematode and root-rotting fungi. This selection was tested in the greenhouse at Salinas, Calif., in 1964, under severe exposure to Heterodera schachtii and Rhizoctonia solani. Of 96 plants tested, 8 of 101-7 survived and all of US 41

were killed. Although 4 of the 8 plants were damaged by *Rhizoctonia*, they recovered and are being brought to seed production.

Suggested utilization: Make further tests for tolerance to combination of *Heterodera schachtii* and *Rhizoctonia* rot.

Item 6. C 057-15 Multigerm 1 pound

Selection from US 56/2 for resistance to *Heterodera schachtii*, using the polycross method. This breeder seed represents the third successive selection for resistance to *Heterodera schachtii*. Tests with C 057-15 are reported in Sugarbeet Research, 1963 Report.

Suggested utilization: Use as pollinator to produce experimental quantities of hybrid seed.

C. Developments in breeding and genetic research by Helen and V. F. Savitsky:

Item 7. S-205 Tetraploid Multigerm 1 pound

Tetraploid, leaf-spot-resistant, self-sterile multigerm line which showed good combining ability in production of triploid monogerm hybrids. In experiments conducted by J. O. Gaskill, Fort Collins, Colo., leaf spot resistance of S-205 is approximately equal to that of US 401.

Suggested utilization: Increase and use as pollinator for 2ⁿ male-sterile monogerm lines for production of leaf-spot-resistant monogerm triploid hybrids.

Item 8. S-206 Tetraploid Multigerm 1 pound

Tetraploid, leaf spot- and curly-top-resistant, self-sterile multigerm line. Derived from hybridization of curly-top-resistant and leaf-spot-resistant tetraploids and propagation of hybrids during several generations. In experiments conducted by J. O. Gaskill, Fort Collins, Colo., leaf spot resistance of S-206 is approximately equal to that of US 401.

Item 8 (cont.)

Suggested utilization: Increase and use as pollinator for 2 \square male-sterile monogerm lines for production of leaf-spot- and curly-top-resistant triploid monogerm hybrids.

Item 9. S-303 Tetraploid Monogerm 1/2 pound

Self-fertile monogerm tetraploid line that is extremely curly top resistant.

Suggested utilization: Increase and use as pollinator for 2 \square male-sterile monogerm lines for production of curly-top-resistant monogerm triploid hybrids. May be used also in breeding program with tetraploid strains.

II. Sugarbeet Investigations, Fort Collins, Colorado.

Developments in breeding research by J. O. Gaskill:

Item 10. FC 502/2 Monogerm 1/2 pound

Monogerm, type-0, rr, S₂ inbred with high sucrose and high leaf spot resistance (a subline of FC 502, described on page 11, Sugarbeet Research, 1963 Report); key strain no. SP 602008sl. For combining ability data and other information, see Sugarbeet Research, 1963 Report, pages 181, 182, and 186.

Suggested utilization: Increase FC 502/2 and its male-sterile equivalent, FC 502/2-CMS (Item 11).

Item 11. FC 502/2-CMS Monogerm 1/2 pound

Monogerm, rr, male-sterile equivalent of FC 502/2.

Increase, using FC 502/2 as pollinator.

Item 12. FC 504 Monogerm 1/2 pound

Monogerm, type-0(\pm), rr, leaf-spot-resistant inbred line; derived (by selfing) from V. F. Savitsky's no. 6-2 (mm line obtained from the cross US 216 MM X SLC 101 mm); key strain no. SP 592013sl. For combining ability

Item 12 (cont.)

data and other information, see Sugarbeet Research, 1963 Report, pages 181, 182, and 186 (line referred to as SP 592013s1).

Suggested utilization: Increase FC 504 and make FC 502/2-CMS \times FC 504 the F₁. On the basis of a preliminary trial, the F₁ is expected to be male sterile.

III. Plant Industry Station, Beltsville, Maryland.

Developments in breeding research by G. E. Coe:

Item 13. SP 6423-0 Monogerm 20 pounds

An O-type with some resistance to leaf spot and black root. This item is the Beltsville increase of SP 6323-0 (Item 24, 1963 Sugarbeet Research) and was rogued for morphological deviates.

Item 14. SP 6423-01 Monogerm 20 pounds

Male-sterile equivalent of SP 6423-0.

Item 15. SP 6426-0 Monogerm 2 pounds

An inbred line which is near O-type but which produced a few yellow-anthered plants in its male-sterile equivalent progeny. It has moderate resistance to leaf spot and black root. Its combining ability has not yet been evaluated.

Item 16. SP 6426-01MS Monogerm 2 pounds

Male-sterile equivalent of SP 6426-0.

Item 17. SP 64194-0 Monogerm 4 pounds

Selections from progenies originating from SP 60194-01 and showing improvement in leaf spot resistance, sugar percentage, and purity.

Item 18. SP 6427-0 Multigerm 1 pound

Selections from SP 5822-0 for improvement in resistance to black root.

IV. Crops Research Laboratory, Logan, Utah.

Developments in the breeding research of J. C. Theurer and associates - G. K. Ryser, C. H. Smith, and E. H. Ottley:

Item 19. SL 14500 Monogerm Annual 1 pound

A pollinator that is near O-type. (See Item 9, pages 8 and 15, 1961 Sugar Beet Research.)

Item 20. SL 14500HO Monogerm Annual 1 pound

Male-sterile phase of SL 14500 (see Item 19)
For further information, see Item 9, pages 8 and 15, 1961 Sugar Beet Research.

Items 19 and 20 have been improved with respect to type-0 condition over Items 9 and 10 of the same SL number proposed for use in 1962. See 1962 Sugarbeet Research, page 9.

BEET SUGAR DEVELOPMENT FOUNDATION

P. O. BOX 538
FORT COLLINS, COLORADO
80522

UTILIZATION OF USDA SEED RELEASES, 1964

ITEM NUMBERS AND SEED NUMBERS ARE IDENTICAL WITH THOSE
LISTED IN THE RELEASE MEMORANDUM DATED MAY 26, 1964^{1/}

1. U. S. AGRICULTURAL RESEARCH STATION, SALINAS, CALIFORNIA

A. DEVELOPMENTS IN BREEDING RESEARCH BY J. S. McFARLANE AND ASSOCIATES, B. L. HAMMOND AND I. O. SKOYEN:

ITEM 1. C3534 MONOGERM

FROM THE QUANTITY OF AVAILABLE SEED THE FOLLOWING DISTRIBUTION
SHOULD BE MADE NOW: AMALGAMATED - 25 GRAMS; AMERICAN CRYSTAL - 25
GRAMS; SPRECKELS - 20 GRAMS; UNION - 25 GRAMS; UTAH-IDAHO - 25 GRAMS.
THE BALANCE OF THE AVAILABLE SEED WILL BE USED FOR AN INCREASE BY
THE WEST COAST BEET SEED COMPANY IN WHICH THE FOLLOWING COMPANIES
WILL PARTICIPATE: AMERICAN CRYSTAL; F & M; GREAT WESTERN; HOLLY;
SPRECKELS; AND UNION.

ITEM 2. C3534H4 MONOGERM

THE UTILIZATION OF THIS ITEM WILL BE IDENTICAL IN AMOUNTS AND
BY COMPANY INTEREST AS FOR ABOVE ITEM 1.

ITEM 3. C321 MULTIGERM

THE AMOUNT OF SEED AVAILABLE WILL BE DISTRIBUTED IN EQUAL AMOUNTS
TO THE FOLLOWING COMPANIES: AMALGAMATED; AMERICAN CRYSTAL; GREAT
WESTERN; HOLLY; SPRECKELS; UNION AND UTAH-IDAHO.

ITEM 4. C3539T MULTIGERM

THE AMOUNT OF SEED AVAILABLE WILL BE DISTRIBUTED AS FOLLOWS:
AMALGAMATED - 25 GRAMS; GREAT WESTERN - 50 GRAMS; UTAH-IDAHO 25
GRAMS; AND FOUR COMPANIES, AMERICAN CRYSTAL, HOLLY, SPRECKELS AND
UNION WILL SHARE THE BALANCE.

1/ MEMORANDUM TO JAMES H. FISCHER FROM DEWEY STEWART WITH THE SUBJECT
"PROPOSALS FOR SEED INCREASE AND UTILIZATION."

B. DEVELOPMENTS IN BREEDING FOR NEMATODE RESISTANCE, BY CHARLES PRICE:

ITEM 5. 101-7 MULTIGERM

FROM THE QUANTITY OF SEED AVAILABLE THE FOLLOWING DISTRIBUTION WILL BE MADE: AMALGAMATED - 25 GRAMS; AMERICAN CRYSTAL - 25 GRAMS; GREAT WESTERN - 25 GRAMS; SPRECKELS - 50 GRAMS; AND THE BALANCE TO UTAH-IDAHO.

ITEM 6. C057-15 MULTIGERM

FROM THE QUANTITY OF SEED AVAILABLE THE FOLLOWING DISTRIBUTION WILL BE MADE: AMALGAMATED - 25 GRAMS; AMERICAN CRYSTAL - 25 GRAMS; GREAT WESTERN - 25 GRAMS; SPRECKELS - 50 GRAMS; AND BOTH UNION AND UTAH-IDAHO WILL SHARE THE BALANCE.

C. DEVELOPMENTS IN BREEDING AND GENETIC RESEARCH BY HELEN AND V. F. SAVITSKY:

ITEM 7. S-205 TETRAPLOID MULTIGERM

FROM THE QUANTITY OF SEED AVAILABLE THE FOLLOWING DISTRIBUTION WILL BE MADE: AMALGAMATED - 25 GRAMS; UTAH-IDAHO - 25 GRAMS; THE BALANCE WILL BE SHARED BY AMERICAN CRYSTAL, GREAT WESTERN, HOLLY, SPRECKELS AND UNION.

ITEM 8. S-206 TETRAPLOID MULTIGERM

DISTRIBUTION OF THE QUANTITY OF SEED AVAILABLE WILL BE MADE IDENTICAL WITH THAT NOTED FOR ITEM 7.

ITEM 9. S-303 TETRAPLOID MONOGERM

DISTRIBUTION OF THE QUANTITY OF SEED AVAILABLE WILL BE MADE IDENTICAL WITH THAT NOTED FOR ITEM 7.

II. SUGARBEET INVESTIGATIONS, FORT COLLINS, COLORADO. DEVELOPMENTS IN BREEDING RESEARCH BY J. O. GASKILL:

ITEM 10. FC 502/2 MONOGERM

NO CURRENT DISTRIBUTION WILL BE MADE; THE ENTIRE QUANTITY OF SEED WILL BE USED FOR INCREASE AND IN COMBINATION WITH FC 502/2 - CMS MONOGERM. THE INCREASE WILL BE SHARED BY THE FOLLOWING: AMERICAN CRYSTAL; F & M; GREAT WESTERN; HOLLY; UTAH-IDAHO; NATIONAL; AND 1 POUND OF THE INCREASE FOR SPRECKELS. STECKLINGS FROM THE INCREASE WILL BE MADE AVAILABLE TO AMERICAN CRYSTAL, HOLLY, SPRECKELS AND UTAH-IDAHO.

ITEM 11. FC 502/2-CMS MONOGERM

THE AVAILABLE QUANTITY OF SEED WILL BE UTILIZED AS NOTED IN ITEM 10. THE SAME USE OF STECKLINGS WILL BE MADE AS NOTED FOR ITEM 10.

ITEM 12. FC 504 MONOGERM

FROM THE AVAILABLE QUANTITY OF SEED THE FOLLOWING DISTRIBUTION WILL BE MADE: AMERICAN CRYSTAL - 20 GRAMS; GREAT WESTERN - 25 GRAMS; SPRECKELS - 20 GRAMS; UTAH-IDAHO - 25 GRAMS; HOLLY - 25 GRAMS. THE BALANCE OF THE AVAILABLE SEED WILL BE USED FOR AN INCREASE BY THE WEST COAST BEET SEED COMPANY FOR NATIONAL.

III. PLANT INDUSTRY STATION, BELTSVILLE, MARYLAND. DEVELOPMENTS IN BREEDING RESEARCH BY G. E. COE.

ITEM 13. SP 6423-0 MONOGERM

FROM THE AVAILABLE QUANTITY OF SEED THE FOLLOWING DISTRIBUTION WILL BE MADE: SPRECKELS - 1 POUND; THE BALANCE WILL BE SHARED BETWEEN AMERICAN CRYSTAL, F & M, GREAT WESTERN, HOLLY, AND UTAH-IDAHO.

ITEM 14. SP 6423-01 MONOGERM

DISTRIBUTION OF THE QUANTITY OF SEED AVAILABLE WILL BE MADE IDENTICAL WITH THAT NOTED FOR ITEM 13.

ITEM 15. SP 6426-0 MONOGERM

FROM THE AVAILABLE QUANTITY OF SEED THE FOLLOWING DISTRIBUTION WILL BE MADE: AMERICAN CRYSTAL - 25 GRAMS; GREAT WESTERN - 50 GRAMS; HOLLY - 25 GRAMS; SPRECKELS - 50 GRAMS; UTAH-IDAHO - 50 GRAMS. TO PROVIDE STECKLINGS FOR HOLLY AND SPRECKELS, 100 GRAMS WILL BE SENT TO WEST COAST BEET SEED COMPANY. THE BALANCE OF THE SEED WILL BE INCREASED BY THE USDA AT BELTSVILLE, MARYLAND, FOR AMERICAN CRYSTAL AND HOLLY.

ITEM 16. SP 6426-01MS MONOGERM

THE AVAILABLE QUANTITY OF SEED WILL BE UTILIZED IN A MANNER IDENTICAL WITH THAT NOTED FOR ITEM 15.

ITEM 17. SP 64194-0 MONOGERM

FROM THE QUANTITY OF AVAILABLE SEED THE FOLLOWING DISTRIBUTION WILL BE MADE: AMERICAN CRYSTAL - 50 GRAMS; SPRECKELS - 50 GRAMS. THE BALANCE WILL BE SHARED AMONG GREAT WESTERN, HOLLY AND UTAH-IDAHO.

ITEM 18. SP 61427-0 MULTIGERM

FROM THE QUANTITY OF AVAILABLE SEED THE FOLLOWING DISTRIBUTION WILL BE MADE: AMERICAN CRYSTAL - 25 GRAMS; SPRECKELS - 25 GRAMS. THE BALANCE WILL BE SHARED AMONG GREAT WESTERN, HOLLY AND UTAH-IDAHO.

ITEM 19. SL 14500 MONOGERM ANNUAL

ITEM 20. SL 14500H0 MONOGERM ANNUAL

BOTH THE ABOVE ITEMS ARE TO BE INCREASED AT LOGAN, UTAH, SUCH INCREASES TO BE SHARED BY AMALGAMATED, AMERICAN CRYSTAL, GREAT WESTERN, SPRECKELS AND UTAH-IDAHO.

1964 Productions of 1963 Proposals for Seed Increase
(See 1963 Report, pp. 7-19)

1963 Item	Breeder seed description	1964 Production	
		Pounds	Designation
1	C3550 Monogerm	250	F64-550
2	C3550H0 Monogerm	50	F64-550H0
3	C3550H1 Monogerm	<u>1</u> /	<u>1</u> /
4	C3505 Monogerm	0	--
5	C330 Multigerm	55	F64-30
6	C3425 Tetraploid multigerm	347	F64-425T
7	033-1 Multigerm - Nema. res.	0	--
8	019 Multigerm - Nema. res.	0	--
9	060-3 Multigerm - Nema. res.	0	--
10	S-132 Tetraploid multigerm	0	--
11	S-204 Tetraploid multigerm	0	--
12	S-302 Tetraploid monogerm	0	--
13	FC 502 Monogerm	0	--
14	FC 502-CMS Monogerm	0	--
15	FC 503 Monogerm	0	--
16	FC 503-CMS Monogerm	0	--
17	SP 63194-0 Monogerm	4591	SP 63194-0
18	SP 63196-0 Monogerm	0	--
19	SP 63624-0 Monogerm	60 <u>2</u> /	SP 63624-0
20	SP 6122-0 Multigerm	100	SP 6122-0
21	SP 6322-0 Multigerm	9384	SP 6322-0
22	SP 61151-0 Multigerm	250 <u>2</u> /	SP 61151-0
23	SP 6256-0 Multigerm	200 <u>2</u> /	SP 6256-0
24	SP 6323-0 Monogerm	150 <u>2</u> /	SP 6323-0
25	SP 6323-01 Monogerm	500	SP 6323-01

1/ Used in 3-way cross; production record not available.

2/ Estimates

SUGARBEET SEED PRODUCTION IN UNITED STATES, 1955-1964^{1/}

Year of production	100-pound bags			Percent monogerm
	Total	Multigerm	Monogerm ^{2/}	
1955	114,187	114,152	35	Trace
1956	88,279	84,991	3,431	3.9
1957	94,547	83,812	10,735	11.4
1958	109,832	82,571	27,261	24.8
1959	111,788	83,594	28,194	25.2
1960	124,545	49,869	74,676	60.0
1961	95,541	25,227	70,314	73.6
1962	93,416	10,768	82,648	88.5
1963	94,447	12,487	81,960	86.8
1964	133,614	15,777	117,837	88.2

^{1/} Production records from Agricultural Statistics.

^{2/} Mostly from hybridizations in which the pollen parent was multigerm.

P A R T II

DEVELOPMENT AND EVALUATION
of
INBRED LINES AND HYBRID VARIETIES OF SUGARBEETS
SUITABLE FOR CALIFORNIA
and
STUDIES ON POLYPLOIDY

Foundation Projects 24 and 29

J. S. McFarlane
B. L. Hammond

I. O. Skoyen
K. D. Beatty

Cooperators conducting tests:

Holly Sugar Corporation
Spreckels Sugar Company
Union Sugar Division
Southwestern Irrigation Field Station

REPORT ON FOUNDATION PROJECTS 24 AND 29

Summary of Accomplishments - 1964

RELEASE OF US H7 AND US H8--Two monogerm hybrid varieties combining resistance to bolting and curly top were released as US varieties in 1964.

US H7 has the parentage (MS of 562 x 569) x C663. The seed-bearing parent is an F_1 hybrid between the male-sterile equivalent of the monogerm 562 inbred and the 569 inbred. The 562 inbred is an increase of an S_2 monogerm line selected from a cross between the NBl multigerm inbred and a bolting-resistant monogerm line. This inbred combines resistance to bolting and curly top. The male-sterile equivalent of 562 has been produced by crossing 562 to the male-sterile equivalent of NBl and then backcrossing to 562. The 569 inbred is the increase of an S_3 monogerm line and possesses moderate resistance to bolting and curly³ top. The F_1 hybrid MS of 562 x 569 has good vigor, curly-top resistance, bolting resistance, and male sterility. The pollen parent is the same as has been used in the US multigerm hybrids.

The bolting resistance of US H7 is similar to that of the multigerm US H6 variety. The curly-top resistance of US H7 is a little inferior to that of US H6 and losses will occur when the variety is exposed to the more virulent strains of the virus. US H7 is recommended for both winter and spring plantings in the coastal valleys and may be used in all dates of planting in the Imperial Valley. The variety may also be used in those portions of the Central Valley not subject to severe curly top.

US H8 has the parentage (MS of 562 x 569) x NB7. The seed-bearing parent is the same as for US H7. The pollen parent NB7 is the increase of an S_1 multigerm inbred from a cross between US 56 and NBl. NB7 combines very good curly-top resistance with good bolting resistance.

The bolting resistance of US H8 varies with the environment. In the Central Valley, US H8 has shown the best resistance of any of the US varieties. In the coastal valleys, where cool conditions often persist throughout the growing season, US H8 has shown less bolting resistance than US H6. The curly-top resistance of US H8 is equal to, or slightly superior to, that of US H2 and US H6.

US H8 is recommended for winter and spring plantings in the Central Valley. The variety may also be used in the Imperial Valley. US H7 is recommended in preference to US H8 as a monogerm variety for the coastal valleys.

PERFORMANCE OF MONOGERM HYBRID VARIETIES--New monogerm hybrids performed well in 1964. Results of variety tests throughout California demonstrate that monogerm varieties are now available which equal or surpass the best multigerm hybrids in root yield, sucrose percentage, bolting resistance, and curly-top resistance. A summary of the performance of seven monogerm hybrids expressed in percent of the performance of US H6 follows:

<u>Hybrid</u>	<u>No. of tests</u>	<u>Gross sugar</u>	<u>Sucrose percentage</u>
(562HO x 569) x 264	12	101	101
(562HO x 569) x NB7	16	102	102
(569HO x 563) x 663	9	105	101
(569HO x 563) x NB7	9	101	100
(562HO x 546) x 663	10	105	102
(562HO x 546) x NB7	13	101	101
(515HO x 569) x NB7	12	103	102

Results of the 1964 tests indicate that the US monogerm hybrids now being produced are similar in root yield and sucrose percentage. Differences exist in curly-top and bolting resistance. Hybrids involving the NB7 pollen parent tend to react more sharply to different environmental conditions than do those involving the heterozygous 663 pollen parent.

PERFORMANCE OF TRIPLOID HYBRIDS--Comparative tests between diploid and triploid forms of US H6 and US H7 showed that the triploids produced higher root and sugar yields but were lower in sucrose percentage. These results agreed with those obtained in 1963. A summary of the performance of triploid hybrids expressed in percent of the performance of corresponding diploid hybrids follows:

	<u>Year</u>	<u>No. of tests</u>	<u>Gross sugar</u>	<u>Acre yield</u>	<u>Sucrose percentage</u>
US H6 (3n)	1963	16	103	107	96
US H6 (3n)	1964	9	110	113	97
US H7 (3n)	1963	11	102	106	96
US H7 (3n)	1964	11	106	110	96

The triploids were superior to the diploids in bolting resistance and similar in curly-top and yellows resistance. Seed germination of triploid hybrids continued to be low in 1964.

SEED LOTS MADE AVAILABLE THROUGH THE FOUNDATION--A monogerm inbred designated C3534 and combining resistance to bolting and curly top was made available in 1964. This type 0 inbred represents the first backcross to NBl and was selected from a cross between NBl and C2563. Greenhouse and field tests show C3534 to be equal or slightly superior to C2563 in curly-top resistance.

A male-sterile monogerm designated C3534H4 and derived from a cross between 563HO and C3534 was also made available. This male sterile was similar in curly-top resistance to the best multigerm male steriles in the field test at Thatcher, Utah.

A yellows-resistant selection designated C321 was made available. C321 was selected from the type 0, self-sterile line C671 which was distributed in 1956. Tests made at Davis, California, in 1963 showed C321 to be superior in yellows resistance to the parent variety. C321 is equal or superior to US 75 in bolting and curly-top resistance.

A tetraploid multigerm inbred from the NB7 inbred has been designated C3539T. The line is similar to NB7 in curly-top resistance and a little superior in bolting resistance. It lacks vigor and is not recommended for use as a pollen parent in commercial hybrids. C3539T has been crossed with a tetraploid from C663 to produce C3425 (Sugarbeet Research, 1963 Report, page 24).

BOLTING RESISTANCE--Bolting counts were obtained from plantings at Brawley, Salinas, and Tracy, California. Low temperatures persisted throughout the winter and early spring in the Imperial Valley and caused the highest percentage of bolting to be observed in many years. The new monogerm hybrids US H7 and US H8 bolted 11 and 4 percent, respectively, compared with 18 and 43 percent for US H6 and US H2. Bolting counts in a November planting at Salinas were about normal, but those obtained by Dr. D. D. Dickenson from a September planting at Tracy were above normal. The results of the 1963 tests provide additional evidence that the relative bolting resistance of varieties and inbreds is influenced by seasonal environmental conditions. The relative bolting resistance of inbreds such as NBl is markedly different from one location to another and also from year to year in a given location. A somewhat similar situation exists with hybrids, such as US H8, which are made up entirely of inbred components. Bolting percentages for a group of parental lines and hybrid varieties planted at Salinas and Tracy in 1962, 1963, and 1964 are summarized on page 23.

Bolting Percentages

	<u>Salinas</u>			<u>Tracy</u>		
	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>
NB1	79	13	52	27	3	49
NB5	10	4	3	27	6	86
NB6	6	5	2	0	0	3
NB7	40	16	26	21	25	78
546	--	6	19	--	1	68
562	39	17	27	30	1	30
563	16	6	9	--	0	--
515 x 569	72	35	--	58	31	63
562 x 569	32	13	15	63	29	58
562 x 546	--	9	16	--	9	57
US H6	23	14	14	58	33	84
US H7	--	13	18	--	29	69
US H8	--	13	43	--	12	63

CURLY TOP RESISTANCE--Varieties and breeding lines were evaluated in the field at Thatcher, Utah, by A. M. Murphy and in the greenhouse at Salinas in cooperation with Dr. C. W. Bennett. In general, resistance ratings obtained in the greenhouse and field were in agreement. Greater variation in resistance among plants within a variety occurs in the greenhouse than in the field. However, reasonably accurate results can be obtained in the greenhouse by comparing the average resistance rating of approximately 40 plants with similar ratings of standard varieties.

Attempts to select for resistance in the greenhouse have been less successful. Progeny tests of massed seed from plants selected on the basis of mild curly top symptoms have been disappointing. Often the selections are no more resistant than the original lines. The resistance of individual plant progenies of selections from self-fertile populations varied widely. Some progenies were more resistant than the parent and others more susceptible. A modified greenhouse technique was tried in 1964. Seed was saved, without regard to curly-top resistance, from individual plants in segregating self-fertile populations. Eight plants of each segregate (four plants per six-inch pot) were inoculated in the greenhouse. The average resistance rating of eight plants provides a more reliable measure of resistance than does individual plant ratings. Progeny tests of the 1964 selections will be made in 1965.

PRODUCTION OF AUTOTETRAPLOIDS--Dr. B. L. Hammond produced additional tetraploids in new breeding lines. Emphasis during 1964 was placed on tetraploids from yellows-resistant lines. Tetraploids were produced from both self-sterile and self-fertile selections which showed the least damage in yellows-resistance evaluation tests at Davis, California. Efforts are underway to develop tetraploid pollinators which contribute a satisfactory sucrose percentage as well as root yield when used as pollen parents in triploid hybrids. An increase of the cross 663 tetra x NB7 tetra (C3425) showed greater promise than did either 663 tetra or NB7 tetra used singly as pollen parents.

In 1963, Dr. Hammond discovered a haploid sugarbeet seedling in a C₄ tetraploid population. He has now doubled the chromosome number of this haploid through the use of colchicine. This homozygous diploid derived from the annual form of the NBl inbred will be of value in studies requiring a high degree of genetic uniformity. A detailed report of Dr. Hammond's work may be found on pages 60-66.

GERMINATION OF MONOGERM SEED--Work by I. O. Skoyen showed that the germination of monogerm seed was reduced when seed was harvested in the late dough stage of maturity and that the speed of germination was also affected. Germination tests made on blotters were less reliable than were those made in sand or soil, because the blotter tests measured sprouting ability rather than emergence vigor.

Results of tests with mature seed showed hybrid varieties and F₁ hybrids differed in speed of germination and in emergence, but further testing is needed to determine whether genetic differences exist in germinability. A detailed report of Mr. Skoyen's work may be found on pages 53-59.

MONOGERM SEED REDUCES LABOR REQUIREMENTS--The need for thinning can be eliminated through precision planting of monogerm seed to give a desired stand or population of plants. Figure 1, page 32, illustrates a field of US H7 that was planted to a stand (6-inch spacing). The field was hoed one time for weed control. Figure 2, page 33, illustrates a redesigned harvester that reduces labor in experimental plots.

SUMMARY.--Sucrose Percentage of bolting-resistant hybrids in 1964 California variety tests, expressed in percent of US H6

Location	Testing Agency	US H6	63H4	64H4	539H4	63F7	539H7	63H8	539H8	539H1	63TH2	425H4	63TH4
<u>Coastal Area</u>													
Salinas - Dec. plt.	USDA	100	100	103	99	101	98	101	98	101	99	99	99
King City	Union	100	101	102	103	101	98	99	98	104	-	97	98
San Lucas	"	100	101	100	97	99	-	100	100	-	-	101	105
Pattersonville	"	100	102	104	101	100	-	104	106	105	-	102	101
Spreckels - Test 1	Spreckels	100	101	-	99	99	100	98	97	98	99	101	97
Spreckels - Test 2	"	100	99	105	107	-	103	105	99	104	-	112	-
Alisal - Test 1	"	100	-	-	-	-	-	-	-	97	-	-	102
Alisal - Test 2	"	100	98	-	-	-	-	-	-	97	-	-	98
Watsonville	"	100	99	-	98	-	-	-	-	100	-	-	-
<u>Central Valley</u>													
Tulare - Fall	Holly	100	-	103	100	-	97	104	97	-	95	100	97
Merced - Spring	"	100	-	103	101	-	100	-	-	-	97	99	95
Tulare Lake	Spreckels	100	103	103	-	-	-	-	-	-	92	98	94
Dixon	"	100	-	-	102	101	-	102	101	105	-	-	-
Liberty Island	"	100	-	-	-	-	-	-	-	-	98	102	100
Visalia	"	100	101	-	-	-	-	-	-	-	-	-	-
Bakersfield	"	100	105	-	104	102	98	107	-	101	-	-	93
<u>Imperial Valley</u>													
Brawley - Early	USDA	100	98	99	101	101	102	102	105	101	95	102	94
Brawley - Late	"	100	-	104	106	104	106	-	104	106	-	104	99
Imp. Val. - 1st. har.	Holly	100	-	102	102	-	-	-	104	-	98	-	-
" - 2nd.	"	100	-	100	102	-	-	-	103	-	97	-	-
" - 3rd.	"	100	-	104	102	-	-	-	103	-	100	-	-

VARIETY TEST, SALINAS, CALIFORNIA, 1964

Location: Spence Field of the U. S. Agricultural Research Station.

Soil type: Sandy loam.

Previous crops: Barley cover crop, 1961; fallow, 1962; vetch cover crop, 1963.

Fertilizer used: 580 lbs. per acre 10:10:5, preplant.
270 lbs. per acre ammonium sulfate sidedressed
March 27, 1964.
245 lbs. per acre ammonium sulfate sidedressed
May 18, 1964.

Planting date: December 17-18, 1963.

Thinning date: February 11, 1964.

Harvest date: October 1-8, 1964.

Irrigations: Sprinkler irrigation as required up to May 30, 1964.
Subsequently, furrow irrigation used at about ten-day intervals.

Diseases and insects: Infection with virus yellows approaching 100 percent by late June.

Experimental design: One test in a 4 x 4 balanced lattice with ten replications, analyzed as a randomized block, and a second test in a randomized block with four replications. Varieties planted in two-row plots with rows spaced 28 inches apart. Plots 65 feet long.

Sugar analysis: From two ten-beet samples per plot by Spreckels Sugar Company, Spreckels, California.

VARIETY TEST, SALINAS, CALIFORNIA, 1964

(10 replicated plots of each variety)

Planted: December 17-18, 1963
Harvested: October 1-8, 1964

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
263TH2	(MS of NBL x NB5) x 663(4n)	9,710	31.4	15.6	2.6	134
263TH4	(562HO x 569) x 663(4n)	9,650	31.3	15.6	1.7	150
3425H4	(562HO x 569) x 3425(4n)	9,620	30.7	15.7	4.0	140
3616H2	(MS of NBL x NB5) x 3616(4n)	9,580	30.7	15.7	2.0	141
F63-64H2	(MS of NBL x NB5) x 264	9,510	29.2	16.3	2.9	142
3616H4	(562HO x 569) x 3616(4n)	9,490	29.4	16.2	1.2	145
363H8	(562HO x 546) x 663	9,180	28.9	16.0	2.7	145
3425H2	(MS of NBL x NB5) x 3425(4n)	9,160	28.6	16.1	2.8	141
3539H8	(562HO x 546) x NB7	9,120	29.4	15.5	7.4	145
F63-64H4	(562HO x 569) x 264	8,980	27.8	16.2	4.7	144
3539H1	(515HO x 569) x NB7	8,960	28.1	16.0	17.7	145
163H2	(MS of NBL x NB5) x 663	8,480	27.0	15.8	4.6	132
363H7	(569HO x 563) x 663	8,450	26.4	16.0	2.7	149
3539H7	(569HO x 563) x NB7	8,400	27.3	15.4	9.9	141
363H4	(562HO x 569) x 663	8,330	26.4	15.8	5.3	147
3539H4	(562HO x 569) x NB7	8,330	26.6	15.7	21.2	145

General MEAN of all varieties	9,060	28.7	15.9	5.8	Beets
S. E. of MEAN	333	1.16	0.19	0.64	per
Coefficient of Difference (19:1)	932	3.25	0.54	1.8	100'
Coefficient of Variation (%)	11.6	12.8	3.8	34.8	row

(Units 19:1 = $1.979 \times \sqrt{2} \times$ Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S			
		Gross Sugar	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	15	2,660,157	29.69	0.79	335.29
Between replications	9	14,426,040	183.54	4.01	6.27
Remainder (Error)	135	1,108,338	13.52	0.37	4.13

Total 159

Calculated F value 2.40** 2.20** 2.14* 81.18**

* Exceeds the 5% point of significance (F=1.72)

** Exceeds the 1% point of significance (F=2.15)

VARIETY TEST, SALINAS, CALIFORNIA, 1964

(4 replications of each variety)

Planted: December 17-18, 1963
Harvested: October 1, 1964

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
234	YRS 810/58	11,360	33.8	17.0	2.9	139
263TH1	(MS of NB1 x NB3) x 663 (Tetra)	10,940	35.0	15.7	3.9	142
3594H2	85HO x 3594	10,570	33.9	15.7	6.1	145
3539H9	(562HO x 549) x NB7	10,530	34.6	15.3	7.1	145
163H2	(MS of NB1 x NB5) x 663	10,280	32.7	15.7	6.6	153
384H7	(569HO x 563) x 384	10,240	31.9	16.1	8.2	144
3506H2	85HO x 3506	10,120	30.8	16.6	4.9	148
063H3	(MS of NB1 x NB4) x 663	10,100	33.3	15.2	5.4	150
3539TH7	(569HO x 563) x NB7 (Tetra)	10,090	33.0	15.4	3.6	139
3534H2	85HO x 2534	9,990	31.5	15.9	7.4	144
3646-32-5H2	85HO x 3646-32-5	9,940	30.9	16.2	4.1	145
363H9	(562HO x 549) x 663	9,920	29.6	16.8	1.7	151
3539TH8	(562HO x 546) x NB7 (Tetra)	9,840	32.0	15.3	2.9	142
3539TH2	(MS of NB1 x NB5) x NB7 (Tetra)	9,570	30.8	15.6	13.6	132
263H1	(MS of NB1 x NB3) x 663	9,550	29.5	16.2	11.3	141
321	YRS 671	9,010	29.8	15.2	11.2	146
368	US 75	8,520	27.2	15.7	2.6	147
3646-32-5H4	(562HO x 569) x 3646-32-5	8,480	25.5	16.7	10.9	152
3423H2	85HO x 3423 (Tetra)	7,850	24.3	16.2	2.3	141
3423H4	(562HO x 569) x 3423 (Tetra)	7,380	24.0	15.5	8.9	145

General MEAN of all varieties	9,700	30.7	15.9	6.3	Beets
S. E. of MEAN	509	1.91	0.34	0.93	per
Significant Difference (19:1)	1,439	5.4	1.0	2.6	100'
Coefficient of Variation (%)	10.5	12.5	4.3	29.5	row

Odds 19:1 = $2.0 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S			
		Gross Sugar	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	19	4,054,072	42.36	1.23	48.68
Between replications	3	25,243,758	277.29	.87	14.85
Remainder (Error)	57	1,035,481	11.60	.46	3.43

Total 79

Calculated F value 3.92** 2.90** 2.67** 14.19**

** Exceeds the 1% point of significance (F=2.23)

Percent bolting in sugarbeet hybrids and selections planted at Salinas, California, November 18, 1963.

Variety	Description	Date of Counting		
		6-11-64	7-21-64	9-10-64
		Percent	Percent	Percent
<u>Three-way hybrids</u>				
263TH4	US H7 (triploid)	1.4	8	9
263TH2	US H6 (triploid)	1.4	8	10
3616H4	(562H0 x 569) x 3616	2.9	8	11
363H9	(562H0 x 549) x 663	0.5	8	13
363H7	(569H0 x 563) x 663	1.6	8	14
163H2	US H6	1.8	11	14
363H8	(562H0 x 546) x 663	1.8	9	14
3425H4	(562H0 x 569) x 3425	1.7	10	14
3539TH8	(562H0 x 546) x NB7 (tetra)	0.8	9	14
F63-64H4	US H7	1.2	12	16
263TH1	US H2 (triploid)	2.7	13	17
F63-64H2	US H6	1.8	13	18
384H7	(569H0 x 563) x 384	1.0	12	18
363H4	US H7	1.7	13	18
3539TH4	(562H0 x 569) x NB7 (tetra)	2.0	12	18
3539TH7	(569H0 x 563) x NB7 (tetra)	1.5	13	19
3539H8	(562H0 x 546) x NB7	5.0	16	20
3539H9	(562H0 x 549) x NB7	2.3	14	23
263H1	US H2	5.1	22	27
3539H7	(569H0 x 563) x NB7	3.9	26	32
3539H1	(515H0 x 569) x NB7	2.9	33	42
3539H4	US H8	9.4	37	43
<u>Single-cross hybrids</u>				
F60-512H1	MS of NB5 x NB6	0.2	5	9
3546-22-5H3	562H0 x 546-22-5	0.3	5	10
F63-549H3	562H0 x 549	0.2	5	11
F63-569H4	563H0 x 569	0.5	5	11
F63-546H4	563H0 x 546	0.8	9	14
F63-569H3	562H0 x 569	0.4	10	15
F63-546H3	562H0 x 546	0.7	9	16
1547H1	MS of NB1 x NB5	1.0	9	16
3534H4	563H0 x 534	0.7	8	16
F60-547H1	MS of NB1 x NB5	1.4	17	24
3550H4	563H0 x 550	1.2	18	26
F63-569H1	515H0 x 569	0.3	18	29
3646-32-5H4	563H0 x 646-32-5	2.9	23	32
<u>Open-pollinated lines</u>				
F62-63T	663 tetra	0.3	2	3
3425	663 (tetra) x NB7 (tetra)	0.3	3	5
330	YRS US 75	0.7	5	7
368	US 75	1.6	8	10
F57-63	Inc. 663	1.1	8	11
F63-64	Bolt. res. 663	1.2	8	12
	L.S.D. (5%)	-	5.9	6.5

Percent bolting in sugarbeet inbreds planted at Salinas, California,
November 18, 1963.

Inbred	Description	Date of Counting		
		6-11-64	7-21-64	9-10-64
		Percent	Percent	Percent
F60-512	NB6	0	1	2
3616	S ₂ (0139 x 0407-1mm)	0	2	2
3559-3	B6lt. res. inbred from NB1	0	2	2
1547	NB5	0	2	3
F58-554	NB4	0	1	4
F63-563	mm inbred	0	8	9
F63-546HO	MS of 546	0	7	11
F63-563HO	MS of 563	0	7	11
F60-547	NB5	1.9	11	17
3559-3H1	MS of 559	4.1	14	18
F63-546	mm inbred	3.2	16	19
3546-22-5	mm inbred	2.8	13	20
F63-562H4	563HO x 562	0	11	21
3534	mm inbred	2.5	15	21
3716-18	Yellows res. inbred	9.0	20	22
0539	NB7	2.0	15	26
3646-32-5	Inc. S ₄ (673-2 x 4502)	1.1	19	27
F61-562	mm inbred	2.0	17	27
3539T	NB7 (tetra)	6.8	24	28
F62-562HO	MS of 562	0	14	28
F63-549	mm inbred	0.6	17	31
3550HO	MS of 550	5.5	24	32
3550	mm inbred	5.9	26	33
F59-569HO	MS of 569	1.7	30	34
F63-648-11	mm inbred	1.7	30	36
F63-648-3	mm inbred	18.8	36	43
F56-502	NB1	15.2	38	52
F59-569	mm inbred	17.8	50	57
F58-502HO	MS of NB1	15.0	61	74
	L.S.D. (5%)	--	10.6	11.0



Figure 1.--The US H7 monogerm sugarbeet variety planted to a stand (6-inch spacing) near Salinas, California, and hand hoed only one time.



Figure 2.--A 1-row commercial sugarbeet harvester adapted to plot harvest. A weighing basket fitted to a beam scale is used to obtain plot weights. A random sugar sample of approximately 10 beets is obtained by lowering a basket into the flow of beets from the cleaning Reinks. (The weighing and sampling devices were patterned from similar equipment developed by Spreckels Sugar Co.)

LEAF SPOT RESISTANCE EVALUATION, 1964
Hospital Farm, Fort Collins, Colorado
Experiment No. 10A

(Conducted by J. A. Elder & J. O. Gaskill)

Description	Contributor's: Ft. Collins: Entry:			Leaf Spot b/			Vigor c/	
	: no. a/	: seed no.	: no. :	8/4 :	8/19:	8/26 :	: 8/4 :	: :
LSR sel. S ₄ (673-2 x 5570)	F63-648-3		355	1.5	2.5	2.5	5.5	
do.	F63-648-11		356	0.8	1.8	1.8	4.0	
SLC 129ms x 2648	F63-648H2		357	1.0	3.5	3.8	6.5	
F61-562H0 x 2648	F63-648H3		358	1.0	2.3	2.3	6.5	
Inc. S ₁ (984 x 0648-9-1)	3612-1C2		359	1.5	3.0	3.0	5.5	
do.	3612-3C2		360	1.0	4.0	3.5	5.5	
do.	3612-5C2		361	1.0	2.0	2.3	6.0	
do.	3612-7		362	1.5	2.3	2.5	6.5	
do.	3612-19		363	1.0	2.5	2.5	6.0	
LSR sel. S ₂ (673-2 x 4502)	3646-5C1		364	1.8	2.3	2.5	3.0	
Inc. S ₄ (673-2 x 4502)	3646-32-5		365	1.8	5.0	6.5	4.0	
F61-569H3 x 3646-32-5	3646-32-5H4		366	2.5	6.5	7.0	5.5	
Inc. S ₁ (0648-3-3 x 0672-5)	3655C2		367	1.8	3.3	3.5	5.0	
S ₁ (984 x 1561-16-7)	3575C1		368	1.3	2.8	3.3	5.0	
Bolt. res. sel. US 201B	384		369	1.0	2.0	2.0	6.5	
2563H1 x 384	384H7		370	0.5	2.5	2.8	7.0	
Bolt. res., CTR sel. US 201B	388		371	1.0	3.0	3.0	6.5	
Monogerm inbred	3550		372	2.5	6.5	6.5	4.0	
2563H0 x 3550	3550H4		373	2.0	4.0	4.8	5.0	
Monogerm inbred	F63-563		374	2.0	3.5	3.5	3.0	
SP 5822-0	WC 3378	Acc. 2591	375	0.5	1.0	1.0	7.0	
SP 5481-0	EL-1023	Acc. 2483	376	1.0	2.1	2.4	7.0	
Synthetic Check (Europ.)	WC 0464	Acc. 2269	377	2.5	5.0	5.8	6.0	

a/ Except for the 3 check varieties (entry numbers 375-377, inclusive), all seed was furnished by J. S. McFarlane, Crops Research Division, A.R.S., U.S.D.A., Salinas, California

b/ Leaf spot: 0 = no leaf spot; 10 = complete defoliation.

c/ Foliage vigor: Larger no. = greater vigor

Field Plan: Plots 2 rows x 12'; rows 20" apart; 2 plots of each entry except 376 which occurred in 4 plots. Artificial inoculation and frequent sprinkling were employed to promote the development of leaf spot.

Remarks: Stand was satisfactory throughout.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1963-64

Location: U.S. Dept. of Agriculture, Southwestern Irrigation Field Station 1/

Soil Type: Holtville Silty Clay Loam

Previous Crops: Sugarbeets - 1960-61; Sesbania - 1961; Sugarbeets - 1961-62; Sesbania and Sweet Sorghum - 1962; Barley - 1962-63;

Fertilizer used: 44 lbs. of actual phosphorous (elemental) preplant
60 lbs. of actual Nitrogen preplant. Sidedressed with
160 lbs. actual nitrogen on November 4, 1963.

Planting date: September 13, 1963 (watering date)

Thinning date: September 30 - October 2, 1963

Harvest date: Early harvest - May 6-8, 1964. Late harvest - June

Irrigations: Early harvest - seven irrigations plus 2.20 inches
of rainfall. Late harvest - eight irrigations plus
2.20 inches of rain.

Diseases and insects: Curly top, virus yellows, and mosaic were
all present in the 1963-64 test but were presumed of
minor importance. On September 25, 1964, and October 4,
1964, the beets were sprayed with 12 oz. of dieldrin/acre
and 2 lbs. of malathion/acre, respectively, for the control
of Cabbage Beetles and Desert Fleg Beetles. Thimet
granules were applied January 13, 1964, using 5% granules
at the rate of 20 lbs./acre.

Experimental Design: Ten varieties planted in a 10 x 10 latin square
using two-row plots for the late harvest; and 15 varieties
replicated 10 times in two-row plots plus 18 varieties
replicated 10 times in single-row plots for the early
harvest.

Sugar Analysis: In the two-row plots, two ten-beet samples per plot
run by Holly Sugar Corp., Brawley, California. One ten-
beet sample was obtained from the single-row plots.

Remarks: Test designed and results analyzed by the U.S. Agricultural
Research Service Station, Salinas, California.

1/ Plot under the supervision of K.D. Beatty, Research Agronomist,
at the Southwestern Irrigation Field Station, Brawley, Calif.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1964

(10 replications of each variety)

Planted: September 13, 1963
Harvested: May 6-8, 1964

Variety	Description	Acre Yield		Sucrose	Bolting	Harvest
		SUGAR Pounds	Beets Tons			Count Number
263TH2	(MS of NB1 x NB5) x 663 (Tetra)	7,840	28.8	13.6	2.3	140
F63-64H4	(562HO x 569) x F63-64	7,830	27.8	14.1	2.7	159
363H7	(569HO x 563) x 663	7,800	27.1	14.4	2.9	156
3539H7	(569HO x 563) x NB7	7,760	26.7	14.6	1.3	148
363H8	(562HO x 546) x 663	7,740	26.5	14.6	4.1	148
3425H4	(562HO x 569) x 3425 (Tetra)	7,670	26.4	14.6	0.3	151
3539H8	(562HO x 546) x NB7	7,630	25.5	15.0	1.7	155
2539H4	(562HO x 569) x NB7	7,570	26.3	14.4	0.5	149
263H4	(562HO x 569) x 663	7,520	26.8	14.0	2.5	150
263TH4	(562HO x 569) x 663 (Tetra)	7,460	27.7	13.5	1.5	147
163H2	(MS of NB1 x NB5) x 663	7,460	26.1	14.3	5.1	149
2539H1	(515HO x 569) x NB7	7,400	25.5	14.5	3.9	152
263H1	(MS of NB1 x NB3) x 663	7,390	26.8	13.8	26.3	149
3425H2	(MS of NB1 x NB5) x 3425 (Tetra)	7,290	26.1	14.0	0.3	150
3616H4	(562HO x 569) x 3616 (Tetra)	7,050	24.0	14.7	6.7	146
General MEAN of all varieties		7,560	26.5	14.3		Beets
S. E. of MEAN		152	0.50	0.18		per
Significant Difference (19:1)		425	1.41	0.50		100'
Coefficient of variation (%)		6.35	6.01	3.94		row

Odds 19:1 = 1.979 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	14	504,402	12.54	1.79
Between replications	9	233,867	6.26	1.54
Remainder (Error)	126	230,239	2.54	0.32
Total	149			
Calculated F value		2.19*	4.94**	5.65**

* Exceeds the 5% point of significance (F=1.77)

** Exceeds the 1% point of significance (F=2.23)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1964

(10 replications of each variety)

Planted: September 13, 1963
Harvested: May 6-8, 1964

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
F63-64H4	(562HO x 569) x F63-64	8,700	30.8	14.1	4.2	142
363HL1	(561HO x 546-36) x 663	8,460	28.3	14.9	3.4	155
3539HL1	(561HO x 546-36) x NB7	8,250	27.0	15.3	3.7	149
163H2	(MS of NBL x NB5) x 663	8,160	28.5	14.3	2.9	144
263H1	(MS of NBL x NB3) x 663	8,000	27.8	14.4	21.9	147
3539H8	(562HO x 546) x NB7	7,940	26.1	15.2	0.9	161
3539H9	(561HO x 549) x NB7	7,770	25.8	15.1	1.8	142
2539H1	(515HO x 569) x NB7	7,660	25.7	14.9	4.8	150
363H9	(561HO x 549) x 663	7,650	26.6	14.4	1.9	146
384H7	(569HO x 563) x 384	7,640	25.2	15.2	3.8	166
3539H7	(569HO x 563) x NB7	7,590	26.0	14.6	0.5	149
3539TH8	(562HO x 546) x NB7 (Tetra)	7,090	23.4	15.2	0.2	131
3646-32-5H4	(562HO x 569) x 3646-32-5	6,930	22.2	15.0	0.3	150
3413H4	(562HO x 569) x 3413 (Tetra)	6,630	22.1	15.0	1.1	138
3539TH4	(562HO x 569) x NB7 (Tetra)	6,600	21.9	15.1	0.4	126
3539TH7	(569HO x 563) x NB7 (Tetra)	6,530	22.0	14.9	1.0	132
3423H4	(562HO x 569) x 3423 (Tetra)	6,150	22.2	13.8	3.0	140
3539TH2	(MS of NBL x NB5) x NB7 (Tetra)	5,470	18.6	14.7	0.6	122
General MEAN of all varieties		7,400	25.1	14.8		Beets
S. E. of MEAN		227	0.77	0.18		per
Significant Difference (19:1)		634	2.15	0.51		'100'
Coefficient of Variation (%)		9.69	9.71	3.88		row

Odds 19:1 = $1.976 \times \sqrt{2} \times$ Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	17	7,477,303	92.55	1.75
Between replications	9	678,111	5.96	2.92
Remainder (Error)	153	514,463	5.92	0.33
Total	179			
Calculated F value		14.53**	15.63**	5.32**

** Exceeds the 1% point of significance (F=2.12)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1964

(10 x 10 Latin Square)

Planted: September 12-13, 1963

Harvested: June 10-11, 1964

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Harvest Count Number
		Sugar Pounds	Beets Tons			
263TH4	(562HO x 569) x 663 (Tetra)	9,270	34.0	13.6	6	147
363H7	(569HO x 563) x 663	9,260	32.5	14.2	12	162
F63-64H4	(562HO x 569) x F63-64	9,230	32.7	14.2	11	151
3425H4	(562HO x 569) x 3425 (Tetra)	9,200	32.1	14.3	2	146
2539H4	(562HO x 569) x NB7	9,170	31.6	14.5	4	154
3539H8	(562HO x 546) x NB7	8,640	30.2	14.3	5	158
3539H7	(569HO x 563) x NB7	8,635	29.8	14.5	4	155
2539H1	(515HO x 569) x NB7	8,540	29.6	14.5	12	161
163H2	(MS of NB1 x NB5) x 663	8,520	31.0	13.7	18	151
263H1	(MS of NB1 x NB3) x 663	7,930	29.5	13.4	43	150

General MEAN of all varieties	8,840	31.3	14.1	12.0	Beets
S. E. of MEAN	148	0.47	0.12	1.1	per
Significant Difference (19:1)	418	1.3	0.33	3.09	100'
Coefficient of Variation (%)	5.3	4.7	2.7	29.3	row

Odds 19:1 = $1.994 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S			
		Gross Sugar	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	9	2,061,177	23.97	1.49	1,434
Between replications	9	895,108	12.09	0.36	19
Between columns	9	2,087,428	19.01	1.20	27
Remainder (Error)	72	219,641	2.17	0.14	12

Total 99

Calculated F value 9.38** 11.05** 10.64** 119.5**

** Exceeds the 1% point of significance (F=2.67)

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1964

TEST AREAS:	Variety	SPRECKELS			SPRECKELS			ALISAL			ALISAL			WATSONVILLE		
		Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
	US H6	3.870	29.76	13.0	3.152	34.40	9.2	3.527	24.36	14.5	4.481	30.21	14.9	6.063	39.75	15.3
	363H4	4.041	30.76	13.1	2.983	32.46	9.1				4.583	31.39	14.6	6.045	39.93	15.1
	363H6				3.390	35.03	9.8									
	363H7	4.048	31.61	12.8	3.332	34.23	9.7									
	363H8	3.940	30.82	12.7												
	363H9	3.910	31.64	12.4												
	263TH2	4.093	31.64	12.9												
	263TH4	4.395	34.65	12.6												
	F63-64H2				3.539	35.28	10.1	3.924	26.42	14.8	4.549	31.15	14.6	6.245	40.86	15.3
	F63-64H4				3.536	36.67	9.7									
	3539H1	3.914	30.79	12.7	3.279	34.32	9.6	3.569	25.63	14.0	4.984	34.44	14.5	6.453	42.15	15.3
	3539H4	3.627	28.19	12.9	3.062	31.35	9.8							5.631	37.57	15.0
	3539H7	3.756	28.87	13.0	3.049	32.31	9.5									
	3539H8	3.617	28.71	12.6	2.872	31.58	9.1									
	3539H9	3.560	27.85	12.8	2.917	30.39	9.8									
	3425H4	3.595	27.53	13.1	3.121	30.41	10.3									
	3423H4	3.419	25.82	13.3	2.502	28.26	8.9									
	GENERAL MEAN	3.792	29.68	12.8	3.117	32.99	9.5	3.823	27.05	14.2	4.550	30.97	14.7	6.120	40.68	15.0
	LSD @ P = .05	.448	2.84	NS	.446	4.28	.7	.478	3.05	NS	.468	3.11	.5	.603	3.54	NS
	LSD @ P = .01	.596	3.78	NS	.594	5.69	1.0	.634	4.07	NS	.621	4.13	.7	NS	NS	NS
	S E of Mean	.160	1.02	.28	.160	1.53	.26	.168	1.07	.32	.166	1.11	.19	.214	1.25	.22
	S E % of Mean	4.22	3.44	2.20	5.14	4.65	2.7	4.39	3.97	2.29	3.65	3.57	1.29	3.50	3.07	1.47
	No. Var. in Test	16	16		16	16		8	8		12	12		10	10	
	Planting Date	12-12-63			1-7-64	1-7-64		1-29-64	1-29-64		1-2-64	1-2-64		3-1-64	3-1-64	
	Harvest Date	9-22-64			10-15-64	10-15-64		9-29-64	9-29-64		9-30-64	9-30-64		10-23-64	10-23-64	

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1964

TEST AREAS:	T U L A R E L A K E				V I S A L I A				B A K E R S F I E L D			
	Variety	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.
	US H6	3.152	21.4	14.8	3.944	27.7	14.2	4.35	44.6	9.8		
	363H4	3.210	21.1	15.3	3.568	24.9	14.3	4.59	44.8	10.3		
	363H7							4.76	48.0	10.0		
	363H8							4.79	46.0	10.5		
	363TH4	3.716	26.8	13.9				4.74	52.3	9.1		
	2539H4							4.96	48.5	10.2		
	2539H1							4.57	46.2	9.9		
	3539H7							4.50	46.8	9.6		
	F63-64H4	3.515	23.0	15.3								
	263TH2	3.833	28.0	13.6								
	3425H4	3.756	25.9	14.5								
	F63-64H2	3.703	24.1	15.3								
	GENERAL MEAN	3.425	22.7	15.2	3.766	25.4	14.9	4.62	46.2	10.0		
	LSD @ P = .05	0.391	2.4	0.8	0.489	3.0	0.5	0.59	4.3	0.9		
	LSD @ P = .01	0.519	3.2	1.1	0.649	4.0	0.6	0.78	5.7	1.1		
	S E of Mean	0.139	0.862	0.293	0.174	1.058	0.165	0.21	1.54	0.30		
	S E % of Mean	4.05	3.80	1.93	4.61	4.17	1.11	4.54	3.33	3.00		
	No. Var. in Test	16	16	16	16	16	16	16	16	16		
	Planting Date	1-2-64	1-2-64	1-2-64	1-3-64	1-3-64	1-3-64	1-16-64	1-16-64	1-16-64		
	Harvest Date	8-20-64	8-20-64	8-20-64	7-24-64	7-24-64	7-24-64	8-12-64	8-12-64	8-12-64		

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1964

TEST AREAS:

Variety	D I X O N			D A V I S			L I B E R T Y I S L A N D		
	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
US H6	4.00	24.7	16.3	1.229	8.37	14.8	5.568	35.50	15.7
363H4				0.963	6.40	15.2			
363H7				0.805	5.40	15.2			
363H8				0.760	4.85	15.7			
363H9				1.101	7.34	15.4			
263TH2							5.648	36.81	15.4
263TH4							5.739	36.48	15.7
2539H1	3.54	21.0	17.1	0.651	4.32	15.2			
3539H1									
2539H4	3.67	22.1	16.7						
3539H4				0.483	3.12	15.5			
3539H7				0.470	3.14	14.9			
3539H8				0.442	2.95	15.5			
3539H9				0.586	3.91	15.0			
3425H4							4.310	26.90	16.0
3423H4							4.710	31.13	15.2
263H7	4.32	26.7	16.4						
263H8	4.07	24.7	16.6						
2539H6	3.57	21.5	16.6						
2539H8	3.50	21.5	16.5						
263TH3	3.91	23.5	16.9						
US 75	3.46	21.3	16.3						
GENERAL MEAN	3.84	23.8	16.3	0.894	5.97	15.1	5.305	33.49	15.9
LSD @ P = .05	N.S.	N.S.	0.59	0.504	3.35	N.S.	0.74	4.31	0.58
LSD @ P = .01	N.S.	N.S.	0.78	0.673	4.47	N.S.	0.98	5.72	0.77
S E of Mean	0.266	1.74	0.207	0.173	1.187	0.268	0.261	1.53	0.206
S E of Mean	6.93	7.31	1.27	19.35	19.88	1.77	4.92	4.56	1.30
No. Var. in Test		16			16			16	
Planting Date		6-5-63			4-25-64			3-9-64	
Harvest Date		5-5-64			10-18-64			9-10-64	

Variety Test

1963-64

Coop: Nelson Correll

1st Date of Harvest

Location: IMPERIAL VALLEY, CALIF.

Variety	Source or Description	Gross Sugar	Tons Per Acre	% Sucrose	% T.J.P.	% Bolt.	% C.T.	No. Beets 100' Row
USH6 (3n)	263TH2	6151	22.919	13.42	90.54	.02	5.39	158
F63-64H4	(562HO x 569) x NB663	6013	21.725	13.84	91.59		4.82	175
2539H4	(562HO x 569) x NB7	5967	21.478	13.89	91.68	.02	1.18	178
USH4	L.1144	5770	20.740	13.91	91.43	.04	.67	167
USH6	163H2	5724	20.982	13.64	91.89	.11	4.66	167
3539H8	(562 x 546) x NB7	5682	20.107	14.13	92.90	.05	1.54	173
US75	L.0253	5567	20.361	13.67	91.24	.04	2.01	166
Gen. Mean		5872	21.103	13.86	91.50	.03	2.25	173
SEmean		256A/	.899	.12	.71			
LSD (5%)		716	NS	.35	1.96			
SEM/Gen. Mean (%)		4.36	4.26	.90	.77			

VARIANCE TABLE

Variation Due To:	DF	Tons Beets	Mean Squares % Sucrose	% T.J.P.
Replication	8	20.368	1.802	8.252
Variety	15	5.544	1.008	4.484
Error	120	7.273	.140	1.559
Total	143			
Calc. F.		NS	7.21**	2.88**

** Exceeds 1% Level 2.23

A/ Short Cut Formula

NS Not Significant

Design: 4 x 4 Triple Lattice - 9 reps.

Plot Size: 2 rows (34") x 53' Planted
2 rows x 50' Harvested

Planted: September 10, 1963
Irrigated: September 20, 1963
Harvested: April 13, 1964

Variety Test

1963-64

Coop: Nelson Correll

2nd Date of Harvest

Location: Imperial Valley, Calif.

Variety	Source or Description	Gross Sugar	Tons Per Acre	% Sucrose	% T.J.P.	% Bolt.	No. Beets 100' Row
2539H4	(562H0 x 569) x NB7	8039	27.085	14.84	93.50	2.22	176
3539H8	562 x 546 x NB7	7848	26.196	14.98	93.86	4.24	176
F63-64H4	(562H0 x 569) x NB663	7688	26.457	14.53	92.81	5.68	174
USH6 (3n)	263TH2	7659	27.296	14.03	93.53	7.39	161
USH6	163H2	7219	24.824	14.54	93.22	14.41	174
USH4	L.1444	7107	24.173	14.70	93.61	17.09	167
US75	L.0253	6585	23.982	13.73	93.04	10.01	169
Gen. Mean		7380	25.616	14.40	93.37	8.96	174
SEmean		219A/	.686	.19	.29		
LSD (5%)		613	1.920	.52	.80		
SEm/Gen. Mean (%)		2.97	2.68	1.29	.31		

VARIANCE TABLE

Variation Due To	DF	Tons Beets	Mean Squares % Sucrose	% T.J.P.
Replication	8	104.942	4.704	12.627
Variety	15	12.422	1.762	1.895
Error	120	4.237	.308	.733
Total	143			
Calc. F.		2.93**	5.71**	2.58**

** Exceeds 1% Level 2.23

A/ Short Cut Formula

Design: 4 x 4 Triple Lattice - 9 reps.

Plot Size: 2 rows (34") x 53' Planted
2 rows x 50' Harvested

Planted: September 10, 1963
Irrigated: September 20, 1963
Harvested: May 28, 1964

Curly top similar to 1st Date of Harvest.

Variety Test

1963-64

Coop: Nelson Correll

3rd Date of Harvest

Location: Imperial Valley, Calif.

Variety	Source or Description	Gross Sugar	Tons Per Acre	% Sucrose	% T.J.P.	% Bolt.	% C.T.	No. Beets 100' Row
F63-64H1	(562H0 x 569) x NB663	8509	29.242	14.55	92.78	6.49	11.02	171
USH6 (3n)	263TH2	8304	29.166	14.09	93.34	8.29	5.09	159
2539H1	(562H0 x 569) x NB7	8195	28.494	14.38	92.83	3.22	10.22	176
3539H8	562 x 546 x NB7	7726	26.677	14.48	93.51	4.33	5.77	169
USH6	163H2	7611	27.086	14.05	92.33	18.54	7.72	161
USH1	L.1444	7475	25.304	14.77	93.02	20.69	4.21	161
US75	L.0253	6567	24.287	13.52	92.05	11.62	4.18	167
Gen. Mean		7676	26.646	14.40	92.78	10.14	16.40	170
SEmean		225A/	.702	.19	.29			
LSD (5%)		629	1.965	.52	.81			
SEm/Gen. Mean (%)		2.93	2.64	1.29	.31			

VARIANCE TABLE

Variation Due To:	DF	Mean Squares		
		Tons Beets	% Sucrose	% T.J.P.
Replication	8	108.537	5.972	6.827
Variety	15	20.953	1.926	2.745
Error	120	4.439	.312	.760
Total	143			
Calc. F.		4.72**	6.18**	3.61**

** Exceeds 1% Level 2.23

A/ short cut formula

Design: 4 x 4 Triple Lattice - 9 reps

Plot Size: 2 rows (34") x 53' Planted
2 rows x 50' Harvested

Planted: September 10, 1963

Irrigated: September 20, 1963

Harvested: July 15, 1964

South San Joaquin Fall

1963-64

Coop: Fisher Bros.

NB-CTR Variety Test

Location: Tulare, Calif.

Variety	Source or Description	Gross Sugar	Per Acre	% Sucrose	% T.J.P.	% Bolt.	No. Beets 100' Row
263TH ₁ (3n)	569H ₃ x 663	9368	38.019	12.32	93.02	2.17	179
263TH ₂ (3n)	USH ₆ (3n)	9324	38.624	12.07	91.45	1.55	150
F63-64H ₁	569H ₃ x NB663	9099	34.571	13.16	92.81	2.09	181
363H ₈	(562 x 546) x 663	9077	34.150	13.29	92.84	2.62	187
3425H ₁	(562 x 569) x T3425	9067	35.752	12.68	92.62	4.05	159
2539H ₁	569H ₃ x NB7	9049	35.458	12.76	92.33	4.73	188
163H ₂	USH ₆	8664	34.029	12.73	92.09	2.41	180
3539H ₇	(569 x 563) x NB7	8585	34.841	12.32	91.68	9.43	178
3539H ₈	(562 x 546) x NB7	8544	34.537	12.37	93.02	5.55	186
USH ₁	L.1444	8220	31.834	12.71	92.00	7.39	155
US75	L.0253	7917	32.367	12.23	91.16	3.65	171
Gen. Mean		8404	33.236	12.65	92.28	5.10	175
SEmean		543A/	1.986	.31	1.32		
LSD (5%)		1518	5.548	.87	3.70		
SEm/Gen. Mean (%)		6.46	5.97	2.46	1.43		

VARIANCE TABLE

Variation Due To	DF	Mean Squares		
		Tons Beets	% Sucrose	% T.J.P.
Replication	8	38.522	12.528	36.321
Variety	19	72.503	1.065	3.881
Error	152	35.485	.875	1.759
Total	179			
Calc. F.		2.04**	NS	2.21**

A/ Short Cut Formula

** Exceeds 1% Level 2.00

NS Not Significant

Design: 4 x 5 Rect. Lattice - 9 reps.

PLOT SIZE: 2 rows (30") x 53' Planted
2 rows x 50' Harvested

Planted: December 19, 1963

Harvested: July 21, 1964

South San Joaquin Spring

1964

Coop: Stribling Nursery

CTR Variety Test

Location: Merced, Calif.

Variety	Source or Description	Gross Sugar	Tons Per Acre	% Sucrose	% T.J.P.	No. Beets 100' Row
263TH2	USH6 (3n)	9650	32.535	14.83		145
3425H4	(562HO x 569) x 3425 (3n)	9087	29.892	15.20		146
F63-64H4	(562HO x 569) x NB663	8924	28.135	15.86		166
263TH4	(562HO x 569) x 4n663 (3n)	8898	30.600	14.54		166
USH4	L.1444	8764	28.073	15.61		159
2539H4	(562HO x 569) x NB7	8721	28.096	15.52		168
163H2 (a)	USH6	8630	28.074	15.37		161
3539H7	(569HO x 563) x NB7	8398	27.320	15.37		164
Gen. Mean		8660	27.772	15.60		164
SEmean		415A/	1.245	.26		
LSD (5%)		1158	3.471	.74		
SEm/Gen. Mean (%)		4.79	4.48	1.69		

VARIANCE TABLE

Variation Due To	DF	Mean Squares		
		Tons Beets	% Sucrose	% T.J.P.
Replication	8	190.384	2.743	
Variety	29	22.858	1.544	
Error	232	13.943	.626	
Total	269			
Calc. F.		1.64*	2.47**	

** Exceeds 1% Level 1.79

* Exceeds 5% Level 1.52

A/ Short Cut Formula

Design: 5 x 6 Rect. Lattice - 9 reps.

Plot Size: 2 rows (30") x 53' Planted
2 rows x 50' Harvested

Planted: February 13, 1964

Harvested: September 8, 1964

VARIETY TEST, KING CITY, CALIFORNIA, 1964

Grower and location: A. S. Duarte, King City, California.

Soil type: Sandy.

Previous crops: Alfalfa, 1961 and 1962; sugarbeets, 1963.

Fertilizer used: 300 lbs. per acre 16:20:0, preplant.
200 lbs. per acre ammonium nitrate, first sidedress.
600 lbs. per acre 20:0:0 (liquid) for the second,
third and fourth sidedressings of 200 lbs. each.

Planting date: February 17, 1964.

Thinning date: April 20, 1964.

Harvest date: November 4, 1964.

Irrigations: Seven.

Diseases and insects: Virus yellows infection was light and of minor importance in the 1964 test plots. A light infestation of leaf miner caused some damage in the plots. Scattered infestation of root knot nematode caused moderately severe damage in four replications in one test plot. These replications were abandoned.

Experimental design: One test of 10 varieties planted in a 10 x 10 latin square; six replications were harvested. A second test of 10 varieties replicated four times. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division, Betteravia, California.

Remarks: Heavy frost damage in the field resulted in spotty stand, reducing test reliability. Seed was furnished, test designed, and results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, KING CITY, CALIFORNIA, 1964

(6 replicated plots of each variety)

By Union Sugar Division

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count
		Sugar Pounds	Beets Tons		
263H1	(MS of NB1 x NB3) x 663	12,550	42.8	14.7	116
263TH4	(562HO x 569) x 663 (Tetra)	12,360	45.1	13.7	108
363H7	(569HO x 563) x 663	12,260	43.2	14.2	130
3425H4	(562HO x 569) x 3425 (Tetra)	12,160	44.7	13.6	113
F63-64H4	(562HO x 569) x 264	11,880	41.6	14.3	119
3539H4	(562HO x 569) x NB7	11,820	41.0	14.4	122
363H8	(562HO x 546) x 663	11,810	42.6	13.9	115
3539H8	(562HO x 546) x NB7	11,810	43.2	13.7	124
163H2	(MS of NB1 x NB5) x 663	11,660	41.6	14.0	110
363H4	(562HO x 569) x 663	11,230	39.9	14.1	107
General MEAN of all varieties		11,950	42.6	14.1	Beets
S. E. of MEAN		430	1.33	0.20	per
Significant Difference (19:1)		N.S.	N.S.	0.58	100'
Coefficient of Variation (%)		8.8	7.7	3.56	row

Odds 19:1 = $2.014 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	883,581	15.18	0.74
Between replications	5	1,812,561	27.48	1.61
Remainder (Error)	45	1,109,193	10.66	0.25
Total	59			
Calculated F value		N.S.	N.S.	2.96**

** Exceeds the 1% point of significance (F=2.84)

VARIETY TEST, KING CITY, CALIFORNIA, 1964

(4 replicated plots of each variety)

By Union Sugar Division

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count
		Sugar Pounds	Beets Tons		
3646-32-5H4	(562HO x 569) x 3646-32-5	11,950	39.7	15.0	121
363H9	(562HO x 549) x 663	11,440	41.1	13.9	117
3539H7	(569HO x 563) x NB7	11,090	42.2	13.0	117
3425H2	(NB1 x NB5) x 3425 (Tetra)	10,860	41.0	13.2	98
F63-64H2	(NB1 x NB5) x 164	10,230	37.3	13.8	109
3616H4	(562HO x 569) x 3616 (Tetra)	10,110	33.6	15.0	100
163H2	(MS of NB1 x NB5) x 663	10,090	37.8	13.3	110
339H1	(515HO x 569) x NB7	10,080	36.6	13.8	101
384H7	(569HO x 563) x 384 Bolt. sel.				
	US201B	9,800	34.3	14.3	104
3423H4	(562HO x 569) x 3423 (Tetra)	9,530	34.5	13.8	80
General MEAN of all varieties		10,520	37.8	13.9	Beets
S. E. of MEAN		600	1.26	0.55	per
Significant Difference (19:1)		N.S.	3.67	N.S.	100'
Coefficient of Variation (%)		11.4	6.7	7.9	row

Odds 19:1 = $2.052 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	2,428,367	38.50	1.86
Between replications	3	9,133,690	43.00	3.82
Remainder (Error)	27	1,440,994	6.39	1.22
Total	39			
Calculated F value		N.S.	6.03**	N.S.

** Exceeds the .1% point of significance (F=3.14)

VARIETY TEST, BETTERAVIA, CALIFORNIA, 1964

(8 replications of each variety)

By Union Sugar Division

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count
		Sugar Pounds	Beets Tons		
263TH4	(562HO x 569) x 663 (Tetra)	11,470	42.1	13.6	151
363H4	(562HO x 569) x 663	10,490	38.2	13.7	155
3539H1	(515HO x 569) x NB7	10,300	36.2	14.2	136
363H8	(562HO x 546) x 663	10,040	35.9	14.0	160
F63-64H4	(562HO x 569) x Bolt. res. sel. 663	9,570	34.1	14.1	158
3425H4	(562HO x 569) x 3425 (Tetra)	9,530	34.6	13.8	129
3539H8	(562HO x 546) x NB7	9,470	33.1	14.3	157
3539H4	(562HO x 569) x NB7	9,260	34.0	13.6	138
363H7	(569HO x 563) x 663	9,250	34.2	13.5	157
163H2	(MS of NB1 x NB5) x 663	8,940	33.2	13.5	147
General MEAN of all varieties		9,830	35.6	13.8	Beets per 100'
S. E. of MEAN		448	1.5	0.24	
Significant Difference (19:1)		1,267	4.3	N.S.	
Coefficient of Variation (%)		12.9	12.1	5.0	row

Odds 19:1 = $2 \times \sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	4,558,430	61.56	0.73
Between replications	7	1,590,707	22.45	0.40
Remainder (Error)	63	1,606,122	18.55	0.478

Total 79

Calculated F value 2.84** 3.32** N.S.

** Exceeds the 1% point of significance (F=2.71)

VARIETY TEST, SAN LUCAS, CALIFORNIA, 1964.

Grower and location: Mesa Farms No. 2, San Lucas, California.

Soil type: Sandy loam.

Previous crops: Dryland barley, 1961 and 1962; beans, 1963, first irrigated crop ever planted in the field.

Fertilizer used: 400 lbs. per acre 15:08:00, preplant.
400 lbs. per acre 20% nitrogen (liquid) sidedress.
400 lbs. per acre 20% nitrogen (liquid) second sidedressing.

Planting date: February 18, 1964.

Thinning date: April 17, 1964.

Harvest date: December 2, 1964.

Irrigations: A total of 15 by sprinkler system.

Diseases and insects: Light curly top damage occurred in the field, but other diseases and insects were not a factor in the test plot.

Experimental design: Ten varieties planted in a 10 x 10 latin square. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis: From two ten-beet samples per plot by Union Sugar Division, Betteravia, California.

Remarks: Seed for the test plot was furnished, the test designed and the results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SAN LUCAS, CALIFORNIA, 1964

(10 x 10 Latin Square)

By Union Sugar Division

Variety	Description	Acre Yield		Sucrose Percent	Harvest Count Number
		Sugar	Beets		
		Pounds	Tons		
3425H4	(562H0 x 569) x 3425 (Tetra)	9,710	32.9	14.8	100
263TH4	(562H0 x 569) x 663 (Tetra)	9,500	30.9	15.4	112
3539H8	(562H0 x 546) x NB7	9,210	31.3	14.7	114
F63-64H4	(562H0 x 569) x 264	8,930	30.4	14.7	134
263H1	(MS of NB1 x NB3) x 663	8,690	29.2	14.9	134
363H8	(562H0 x 546) x 663	8,500	29.0	14.7	121
163H2	(MS of NB1 x NB5) x 663	8,470	28.7	14.7	130
363H7	(569H0 x 563) x 663	8,410	28.7	14.6	115
3539H4	(562H0 x 569) x NB7	8,360	29.2	14.3	113
363H4	(562H0 x 569) x 663	8,300	28.0	14.9	126

General MEAN of all varieties	8,810	29.8	14.8	Beets
S. E. of MEAN	294	0.87	0.17	per
Significant Difference (19:1)	N.S.	2.5	0.49	100'
Coefficient of Variation (%)	10.6	9.2	3.7	row

Odds 19:1 = 1.990 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	M E A N S Q U A R E S		
		Gross	Tons	Percent
		Sugar	Beets	Sucrose
Between varieties	9	256,324	22.86	0.70
Between replications	9	216,543	12.54	1.18
Remainder (Error)	81	864,338	7.56	0.30
Total	99			
Calculated F value		N.S.	3.02**	2.33*

* Exceeds the 5% point of significance (F=1.99)

** Exceeds the 1% point of significance (F=2.64)

EFFECT OF MATURITY ON GERMINATION OF SEED OF MONOGERM
HYBRID VARIETIES AND F_1 HYBRIDS OF SUGARBEETS

I. O. Skoyen

The low germination in several 1962 seed increases of US hybrid varieties indicated a need for further investigation to determine the factors responsible. The study of the effect of seed maturity on germination was a main objective of the 1963 testing.

Procedures

Tests were made on samples of seed collected at early-dough and late-dough stages of development, as well as on mature seed. The immature samples were collected in Oregon in early August, 1963 and the mature seed samples were taken from commercially harvested seed. At the time of sampling, seed in the early-dough stage was estimated to be at least two weeks away from full maturity. Seed ball coloration had not yet begun and the seed was formed but very soft. Seed in the late-dough stage, estimated at 7 to 10 days from maturity, showed seed ball coloration, and had a well-formed seed which tended to flake apart when rubbed between the finger tips. Actual harvest of the matured seed averaged 16 days after sampling for the hybrid varieties and 22 days after sampling for the F_1 hybrids.

Seed samples of 12 monogerm hybrid varieties and 7 F_1 hybrids were tested. The monogerm hybrid varieties included combinations of 6 F_1 hybrids with two top-cross pollinators. One pollinator was the self-fertile multigerm NB7 inbred and the other the open-pollinated 663 multigerm or the 164 bolting-resistant selection from 663. In five of the 3-way combinations germination comparisons were obtained between crosses using common F_1 seedbearers with the NB7 and 663 top-cross pollinators.

Random samples of 50 seed balls were used for each seed treatment in the germination tests. The treatments on the late-dough and early-dough samples were:

- A. Whole unsoaked seed balls planted in flats of sand.
- B. Whole soaked seed balls dried in an airstream 1 to 2 hours before planting in flats of sand.
- C. Whole soaked seed balls, blotted to remove excess moisture, and planted (1) on moistened blotters in petri dishes and (2) in flats of sand.
- D. The glandular discs removed from soaked seed balls and the seed placed on moist blotters in petri dishes.

A four-hour seed soak in running tap water was used for the tests. No fungicide treatments were used in the tests, but all sand plantings were made in steam-sterilized sand.

The results of tests on the mature seed samples were used as the check in the experiments. The tests on mature seed corresponded to seed treatment A given above. All check tests were conducted in sand cultures, because evaluation of emergence potential, taken as percent germination, was considered a more realistic comparison with field conditions.

The tests in sand cultures were conducted in the greenhouse and the tests in the petri dishes in the laboratory. Temperatures in the greenhouse ranged from a mean nighttime low of 57° F to a mean daytime high of 86° F. The laboratory tests were made at room temperatures of 63° to 74° F.

Results

The results of the tests made in sand cultures on seed of the monogerm hybrid varieties and the F_1 hybrids are shown in tables 1 and 2. From the data it is apparent that germination of seed harvested early was frequently substantially reduced and that particularly severe reductions occurred in early germination or in the speed of germination. Germination of the unsoaked late-dough-stage seed at 5 days was 14 to 64 percent below the check for the 12 hybrid varieties. The mean reduction was 40 percent. For the same treatment, late-dough-stage seed of the seven F_1 hybrids germinated 8 to 56 percent below the check with a mean reduction of 26 percent. However, at 14-days, germination of late-dough seed for individual varieties ranged from slightly above the check to 38 percent lower. The mean was 17 percent below the check. The mean for the late-dough-stage seed of the F_1 hybrids, after 14 days, was the same as that of the check, but four F_1 hybrids germinated 2 to 18 percent better than the check.

Germination of late-dough seed was not consistently improved in the sand cultures by seed soaking and drying or by soaking alone. Germination was more frequently decreased compared with unsoaked seed tests for both varieties and F_1 hybrids.

Seed samples of the early-dough stage, as expected, germinated poorly. For the varieties it was 50 percent below the check for both 5- and 14-day test periods, and for the F_1 hybrids the reduction was about 30 percent for both intervals. The soaking and drying and soaking only treatments generally reduced germination more than that of the late-dough stage.

Results of sand-culture tests on mature seed showed the hybrid varieties 3539H7, 363H7 and 3539H11, 363H11 germinated 62 to 72 percent in 5 days, indicating a tendency for rapid germination and emergence. In 14 days these combinations had germinated and emerged 80 to 92 percent, among the highest percentages for the varieties tested. Mature seed of two F_1 hybrids, F63-569H4 and F63-569H5, showed substantially higher germination than the other F_1 hybrids at both 5- and 14-day intervals. At 5 days, germination of 569H5 and 569H4 was 25 and 31 percent higher, respectively, than the mean of all F_1 hybrids tested, and at 14 days, it was 17 and 29 percent higher. The good germination and emergence of these two F_1 hybrids suggest a tendency in some inbred seedbearers for uniform seed

maturity and quality similar to that of seed produced on most of the F_1 seedbearers included in the tests. However, the mean emergence percentage for mature seed of the F_1 hybrids was about 20 percent lower than that of the 3-way hybrids and probably reflects greater sensitivity to environmental factors by some of the inbred seedbearers tested than that of the F_1 hybrid seedbearers. One factor which influenced seed quality during the 1963 season was a moderately severe incidence of root rot. Damage appeared to be heaviest in bolting-resistant monogerm inbreds and probably was due in part to a characteristically slower maturity, compared with nonresistant material, lengthening the period of exposure. The 562H0 inbred generally showed the most damage. The diseased plants generally died prematurely and, because of the inclusion of immature seed from such plants in the harvested seed, reduced the quality. Further testing of seed produced in different seasons is needed to establish whether the differences in germination are inherent in some hybrid variety and F_1 combinations, or merely differences in environmental responses.

The results of blotter germination tests on late- and early-dough-stage seed samples, for both varieties and F_1 hybrids are shown in tables 3 and 4. The germination percentages for the soaked whole seed, of both varieties and F_1 hybrids, show the maximum sprouting which may be expected from the seed samples tested. These were as much as 66 percent higher than the check at the 3-day interval for the hybrid varieties and 38 percent higher for the F_1 hybrids. However, these percentages represent sprouting ability only and not the vigor to grow and emerge from sand or soil. The results of tests on seed with the glandular discs removed showed further increases in germination, but mainly because the barriers were removed which may have prevented sprouting. Factors affecting the sprouting of whole seed would include immature partially formed seeds lacking in vigor, seedballs with tightly cemented discs interfering with moisture or oxygen availability for sprouting, and seeds with coats impervious to moisture.

Summary

Results of tests on seed of monogerm varieties and F_1 hybrids showed germination to be severely reduced when seed was harvested in the late-dough stage of maturity but that speed of germination was most seriously affected. The data presented showed that germination tests conducted in blotter cultures produced unrealistic results, because the tests measured sprouting ability rather than emergence vigor.

Data from tests on mature seed showed hybrid varieties and F_1 hybrids differed in speed of germination and/or emergence, but further testing is needed on seed produced in different years to establish the presence of inherent differences or merely differences in environmental responses.

Table 1.--Comparison of germination and emergence in sand planted tests on seed of twelve monogerm hybrid varieties collected at different stages of maturity in Oregon in 1963.

Variety No.	Description	Mature Seed (Check)	PERCENT GERMINATION											
			Late Dough Stage						Early Dough Stage					
			A		B		C		A		B		C	
			Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
		5	14	5	14	5	14	5	14	5	14	5	14	5
3539H1	(515 x 569) x NB7	40	70	2	54	8	72	8	46	2	30	2	30	8
3539H4	(562 x 569) x NB7	42	64	12	66	8	54	22	60	4	22	4	20	14
363H4	(562 x 569) x 663	44	76	4	62	0	36	0	34	0	26	0	14	0
F63-64H4	(562 x 569) x 164	56	88	42	98	36	70	36	62	12	28	20	28	16
3539H7	(569 x 563) x NB7	70	86	8	62	10	54	26	54	6	50	4	36	12
363H7	(569 x 563) x 663	62	82	8	56	30	54	26	50	2	24	10	26	2
3539H8	(562 x 546) x NB7	58	66	38	68	28	46	22	42	2	18	2	8	0
363H8	(562 x 546) x 663	48	58	22	42	38	66	16	50	4	16	2	14	10
3539H9	(562 x 549) x NB7	50	68	0	46	6	40	4	42	2	16	0	30	0
363H9	(562 x 549) x 663	38	62	4	40	4	38	12	34	4	22	6	22	8
3539H11	(562 x 546-36) x NB7	72	80	8	50	8	34	12	32	4	28	6	18	0
363H11	(562 x 546-36) x 663	70	92	10	54	10	32	10	36	6	10	6	10	4
	MEAN	54	75	13	58	16	50	16	45	4	24	5	21	6

Table 2.--Comparison of germination and emergence in sand planted tests on seed of seven F₁ hybrids collected at different stages of maturity in Oregon in 1963.

P E R C E N T G E R M I N A T I O N															
Variety No.	Description	Mature Seed (Check)		Late Dough Stage			Early Dough Stage								
		Days	A		Days	B		Days	A						
			5	14		5	14		5	14					
											Days	Days	Days	Days	
F63-569H1	515H0 x 569	20	44	2	20	8	34	4	10	0					0
F63-546H3	562H0 x 546	8	38	0	56	2	44	8	32	0	20	0	14	0	4
F63-569H3	562H0 x 569	24	52	0	62	0	62	4	14	0	42	4	26	18	52
F63-648H3	562H0 x 648	34	56	18	58	20	58	24	50						
F63-546H4	563H0 x 546	12	38	2	56	2	44	4	42	4	24	0	8	2	20
F63-569H4	563H0 x 569	62	84	6	62	6	44	6	48	0	38	2	24	0	20
F63-569H5	546H0 x 569	56	72	8	64	10	38	8	26	10	38	0	6	0	2
MEAN		31	55	5	54	4	46	8	32	2	23	1	13	3	17

Table 3.--Comparison of germination in blotter tests on seed of twelve monogerm hybrid varieties collected at different stages of maturity in Oregon in 1963.

P E R C E N T G E R M I N A T I O N												
Variety No.	Description	Mature Seed (Check) ^{1/}		Late Dough Stage			Early Dough Stage					
		Days	4 - 11	C			C					
				Days	3	10	Days	3	10	Days	3	10
3539HL	(515 x 569) x NB7	0	70	44	68	44	84	34	50	28	50	
3539H4	(562 x 569) x NB7	2	62	64	74	82	92	42	48	68	74	
363H4	(562 x 569) x 663	20	72	32	56	66	70	24	32	34	40	
F63-64H4	(562 x 569) x 164	6	86	20	82	26	92	22	35	44	59	
3539H7	(569 x 563) x NB7	12	86	52	72	80	82	52	66	58	68	
363H7	(569 x 563) x 663	14	78	52	76	78	88	16	24	60	68	
3539H8	(562 x 546) x NB7	28	66	30	30	56	70	16	24	34	52	
363H8	(562 x 546) x 663	8	58	74	76	86	92	0	4	32	34	
3539H9	(562 x 549) x NB7	8	66	44	60	62	96	24	40	40	54	
363H9	(562 x 549) x 663	0	60	40	62	80	84	28	42	52	64	
3539H11	(562 x 546-36) x NB7	28	80	32	46	70	86	3	22	52	76	
363H11	(562 x 546-36) x 663	16	86	46	76	64	92	4	14	34	56	
	MEAN	12	73	44	65	66	86	22	35	44	59	

^{1/} Check data used from sand culture tests.

Table 4.--Comparison of germination in blotter tests on seed of seven F₁ hybrids collected at different stages of maturity in Oregon in 1963.

P E R C E N T G E R M I N A T I O N												
Variety No.	Description	Mature Seed		Late Dough Stage			Early Dough Stage					
		(Check)	1/ =									
				Days	Days	Days	Days	Days	Days	Days	Days	Days
		4	11	3	10	3	10	3	10	3	10	3
F63-569H1	515H0 x 569	0	42	6	52	30	82	0	4	6	20	
F63-546H3	562H0 x 546	0	36	38	64	50	80	4	16	20	26	
F63-569H3	562H0 x 569	0	50	22	76	54	96	26	56	38	62	
F63-648H3	562H0 x 648	6	52	20	78	28	94					
F63-546H4	563H0 x 546	0	34	20	66	54	84	20	36	42	58	
F63-569H4	563H0 x 569	10	80	40	64	60	76	18	34	42	66	
F63-569H5	546H0 x 569	18	70	18	64	40	82	8	32	36	68	
	MEAN	5	52	23	66	45	85	13	30	31	50	

1/ Check data used from sand culture tests.

DEVELOPMENT OF TRIPLOID AND TETRAPLOID SUGARBEETS

B. L. Hammond

Additional seed increases of the following tetraploid selections are being made for the purpose of making extensive field tests: 1546-22T; 271rrT; 271R-T; 0546-48T; 563T (tetraploid of 1561-16-7C1); 562HO-T X 1546-22T; 871T X 8539T; and 562HO-T X 563T. The identity of these selections may be found in previous reports. Seed was planted in Oregon in August 1964 to obtain stecklings for transplanting to isolation chambers at Salinas in March 1965.

In September 1963, 3.5 gms. of seed from plants with green hypocotyls and 18 gms. from plants with red hypocotyls of the monogerm inbred 0546-36 were harvested. A seed increase is now being made.

Additional seed increases of the male-sterile monogerm tetraploid line from type-0 monogerm inbred 0562 and its male-sterile equivalent, 9561H2, for use with diploid pollinators, are being made.

Seed increases were made from the type 0 multigerm F57-85T and its male-sterile equivalent, F57-85HO-T. Seed increases are being made from the "annual" forms of these lines. (The latter consisted of progeny of 9 plants of F57-85C and 5 plants of F57-85HO C which had bolted prior to thermal induction.) A comparison with tetraploids from nonbolting plants with respect to degree of bolting will be made under field conditions. Bolting in the greenhouse of highly nonbolting commercial varieties not thermally induced apparently had not been observed.

In September 1963, 34 gms. of C_1 seed were harvested from the type-0 monogerm inbred F61-515. A seed increase will be made. Since nearly 100 percent of the parent plants had red hypocotyls, this inbred should be of considerable value in outcrossing studies.

Seedlings of the vigorous multigerm inbred 1547 (from NB5) were colchicine-treated in July 1962 and placed under thermal induction in October. Twenty-eight plants had green hypocotyls, and 20, red hypocotyls. All were removed from the coldroom in April 1963 and each class interpollinated separately. In September, 15 gms. of C_1 seed were harvested from plants with green hypocotyls and 26 gms. from plants with red hypocotyls. For the purpose of securing additional seed from plants with red hypocotyls for use in outcross studies, a second planting of colchicine-treated seedlings of this material was made. Fifty-eight plants having red

hypocotyls were placed under thermal induction in March 1963 and removed in July for interpollination. In January 1964, 29 gms. of C_1 seed were obtained. A seed increase will be made. Tetraploid plants of this selection have been crossed to 2423T (T8 increase) and to 2539T, a multigerm, tetraploid inbred from NB7.

In July 1962, pregerminated seed of multigerm 586 was colchicine treated. On the basis of cytological observations, 62 plants were selected for thermal induction and placed in the coldroom in December. They were removed in July 1963 and interpollinated. Twenty plants had green hypocotyls and 42, red hypocotyls. Twelve gms. of C_1 seed were obtained from plants with green hypocotyls and 18 from the red hypocotyl plants. This selection is an open-pollinated multigerm. It is high in sucrose percentage but low in root yield. Crosses will be made with 663T and with 871T in an attempt to develop a tetraploid top-cross parent with good tonnage and sucrose percentage. Seed for these crosses was planted in March 1964. Plants were placed under thermal induction in June 1964. Additional C_1 seed of 586 was planted also for a small seed increase. Twenty-one plants were placed under thermal induction in May 1964. These were removed in September and sib crossed.

Colchicine-treated seedlings of the multigerm inbred F59-509 (NB3) were planted in August 1962 and transplanted to pots in November. In January 1963, 38 selected C_0 plants were exposed to thermal induction and removed in July for sib crossing. Only 5.2 grams of seed were obtained, some of which was planted in March 1964 for seed increase. All plants have red hypocotyls, a characteristic which will facilitate studies in outcrossing involving tetraploids derived from self-fertile diploid inbreds.

Pregerminated seed of selection F58-554 (NB4) was treated with colchicine and planted in late October. Plants were transplanted to pots in December 1962. Seventy-four selected C_0 plants were placed in the coldroom for thermal induction in March 1963 and removed in August for interpollination. Thirty-seven gms. of C_1 seed were obtained. This selection is a small-seeded, multigerm inbred. All plants have green hypocotyls.

In November 1962, pregerminated seed of selection 2559-1 was colchicine treated. Seedlings were potted in January 1963. Sixty-seven C_0 plants selected on the basis of cytological examination were placed under thermal induction in May 1963 and removed in August for interpollination. After 5 weeks with no evidence of bolting, these plants were returned to the coldroom for further thermal induction. Plants were again removed from the coldroom in March 1964 and later sib crossed. Forty-three gms. of C_1 seed were obtained. This selection is a multigerm inbred similar to NB1. It has red hypocotyls and petioles, characters which will facilitate studies in outcrossing.

Pregerminated seed of selection 164, a bolting-resistant selection from 663, was colchicine treated in June 1963. Seventy-eight selected C₀ plants (68 with red hypocotyls and 10 with green hypocotyls) were placed under thermal induction in September. These were removed in March 1964 and interpollinated. From plants with red hypocotyls, 54 gms. of good seed were obtained. It is doubtful if any good seed was obtained from plants with green hypocotyls.

One hundred fifty-five colchicine-treated seedlings of selection 330 were transplanted to pots in September 1963. Seventy of these (16 with green hypocotyls and 54 with red hypocotyls) were placed in the coldroom for thermal induction in December 1963. Plants were removed from the coldroom in June 1964 and sib crossed. This is a selection from the self-sterile, multigerm US 75 and is yellows resistant.

Colchicine-treated seedlings of selection 952 were planted in July 1963 and transplanted to pots in September. Sixty-seven desirable C₀ plants were selected for thermal induction in January 1964. This is a self-sterile, type-0 selection from US 15. Plants were removed from the coldroom in June 1964 and later interpollinated.

In April 1964, pregerminated seed of the self-fertile multigerm 3757 was colchicine treated. One hundred fifty-five seedlings with red hypocotyls were potted in May. On the basis of cytological examination, 75 of these were placed under thermal induction in July. Thirty-three seedlings with green hypocotyls were potted in June. Nineteen of these were placed in the coldroom in September. This selection is yellows resistant.

Colchicine-treated seedlings of the self-fertile, monogerm inbred 3534 planted in April 1964 were transplanted to pots in July. Of the 155 transplanted, 70 were selected for thermal induction in October. All plants have green hypocotyls. This selection responded well to the 0.3 percent colchicine solution.

Pregerminated seed of the self-fertile, yellows-resistant multigerm 3716-18 was colchicine treated and planted in April 1964. One hundred fifty-five seedlings were transplanted to pots in June. Fifty-two plants (mostly poor chimeras) were placed in the coldroom in August. All plants have red hypocotyls. This selection did not respond well to the 0.3 percent colchicine solution.

One hundred ^{and} five colchicine-treated seedlings of selection 3550 were transplanted to pots in July 1964. Sixty-eight of these (indicating good response to the 0.3 percent colchicine solution) were selected for thermal induction in December. This is a bolting resistant, monogerm inbred.

In August 1964, pregerminated seed of selection 3753 was colchicine treated. One hundred fifty-five seedlings were transplanted to pots in September. On the basis of cytological examination, 52 (including some poor chimeras) were selected for thermal induction in November. This is a yellows-resistant multigerm and has red hypocotyls. This selection did not respond well to the 0.3 percent colchicine solution.

Pregerminated seed of the inbred monogerm 4764 was treated with colchicine and planted in August 1964. Seedlings were highly infected with root rot. Of the 125 seedlings transplanted to pots in November, 21 had green hypocotyls. This selection is yellows-resistant.

Germinating seed of 234, a self-sterile, yellows-resistant selection obtained from Dr. Rietberg, was colchicine treated and planted in November 1964. It has both green and red hypocotyls.

Colchicine-treated seed of the multigerm 413B was planted in November 1964. It is a yellows-resistant selection from US 75. All seedlings have green hypocotyls.

Pregerminated seed of the multigerm, inbred selection 4704 was planted in November 1964. It is also resistant to virus yellows. All seedlings have red hypocotyls.

871T X 0539T.--A history of this cross was given in the 1963 report. Seed was planted in Oregon in August to obtain an additional seed increase for evaluating this cross in field tests.

562HO-T X 1546-22T.--A history of this cross was also given in the 1963 report. Plantings of this new hybrid were made in Oregon in August for additional seed increases.

562HO-T X 563T.--Seedlings of the male-sterile, monogerm inbred line 562HO-T and the tetraploid selection of 1561-16-7C1 (563T) were exposed to thermal induction in July 1963, moved to the greenhouse in February 1964, and crossed. A number of the pollen-fertile parent (563T) was sib crossed. Thirty-two gms. of seed were obtained from 562HO-T X 563T and 17 gms. from 563T. Plantings of both classes of seed were made in Oregon in August for additional seed increases. The diploid form of the latter selection has been made available through the Foundation as C2563. It is a type-0 monogerm and highly resistant to curly top.

2423T (T8 Increase) X 1547T.--In December 1963, seed of 2423T, together with seed of the multigerm inbred 1547T was planted for the purpose of making crosses between these two selections. 2423T is a composite seed increase of a number of T8-line single-plant tetraploid selections derived from S₆(US22/3 X NBL). Plants were

placed under thermal induction in May 1964. The gene for red hypocotyl in 1547T will be used in selecting crosses.

2539T X 1547T.--Also in December 1963, tetraploid seed of the multigerm inbred 2539 (from NB7), together with seed of another tetraploid, multigerm inbred 1547T was planted for the purpose of crossing these two inbreds. Plants were placed in the coldroom in May 1964. Selection 2539T has green hypocotyls. Being also self-fertile, only the red-hypocotyl plants of 1547T will be used in selecting actual crosses.

586T X F62-63T.--C₁ seed of the multigerm 586T, together with seed of F62-63T (663T), was planted in March 1964. Plants were placed under thermal induction in June 1964. 586 is high in sucrose percentage but low in root yield. This cross is being made in an attempt to develop a tetraploid top-cross parent with good tonnage and sucrose percentage.

586T X 271T.--This cross is also being made with the view of developing a tetraploid top-cross parent with good tonnage and sucrose percentage. 271T is a type-0 multigerm. Seed was planted in March 1964. Plants were placed under thermal induction in June 1964.

1547T X 2559-1T.--C₁ seed of the multigerm inbred 1547T, together with C₁ seed of the multigerm inbred 2559-1T, was planted in November 1964. The green-hypocotyl form of 1547T was used, since 2559-1T has red hypocotyls.

Studies will be continued during the coming season to determine the effect of polyploidy on the bolting of annual beets (not requiring thermal induction). Selections 2589C1 and 2541 were selected for this purpose.

During the summer of 1962, the diploid seedlings of the monogerm inbred 0546-36 were heavily infested with spider mites, whereas the tetraploid seedlings intermingled with the diploids showed no signs of having been infested. (See 1963 Report.) A seed increase of the tetraploid form is being made for the purpose of planting in the Imperial Valley in the fall of 1965 to determine its resistance to spider mites under field conditions.

In the spring of 1963, a haploid sugarbeet with 9 chromosomes appeared among 42 C₁ seedlings of the self-fertile annual 2589C1. (See 1963 Report). This plant was readily distinguished from the others by its narrower and more tapered leaves. It flowered profusely during the summer and was pollen sterile.

Having been derived from a self-fertile line, every effort was made to increase the number of plants by vegetative propagation, with the object of creating a fertile, homozygous diploid line by the use of colchicine. Cuttings were made from the flower stalks and, during the following winter, 17 grafts were made from root-crown cuttings. Thirteen flower-stalk cuttings survived, making a total of 30 haploid plants.

During June 1964, flower stalks began to form in the leaf axils of the crowns. Colchicine was applied in the leaf axils at these early stages of growth.

In September, 5.9 gms. of seed were harvested from the first plant treated. Half of this seed was planted immediately for the purpose of making a seed increase. Of the 183 seedlings produced, 171 were diploid, 10 were triploid, and 2 were tetraploid.

One rather striking characteristic of the diploid seedlings is their uniformity in size, color, and in leaf shape. The seed germinated promptly and uniformly.

A comparison of haploid and diploid leaves is shown in figure 1. Triploid and tetraploid leaves tended to be slightly broader than the diploid.

The haploid line is being maintained by flower-stalk cuttings. It is highly susceptible to mite infestation.



Figure 1.--Comparison of leaves of a diploid plant (right) with those of the haploid (left). The diploid form was derived from the haploid by the use of colchicine. Leaf blades of the haploid are characteristically asymmetrical. Leaf margins of the diploid are smoother and less irregular than those of the haploid.

P A R T III

DEVELOPMENT AND EVALUATION OF INBRED LINES
AND HYBRID VARIETIES OF SUGARBEETS
with emphasis on
Curly Top Resistance, Monogermness, and High Quality

- - - - -

STUDIES ON GENETICS OF MALE STERILITY IN THE SUGARBEET

- - - - -

GREENHOUSE TECHNIQUES TO EVALUATE BREEDING MATERIAL
FOR RESISTANCE TO CURLY TOP AND VIRUS YELLOWS

- - - - -

STUDIES ON PURITY EVALUATION,
PHOTOSYNTHESIS, AND RESPIRATION

Foundation Projects 17, 21, and 27

A. M. Murphy
J. C. Theurer
G. K. Ryser

C. L. Schneider

C. H. Smith
Myron Stout
E. H. Ottley

Cooperation:

Utah Agricultural Experiment Station

Asexual Transmission of Cytoplasmic Male Sterility

J. C. Theurer and E. H. Ottley

Studies to ascertain the possibility of transferring cytoplasmic male sterility from one line of sugarbeets to another by asexual means were initiated at Logan in 1962. Grafts were made in all combinations of fertile scion/fertile stock, fertile scion/male-sterile stock, male-sterile scion/fertile stock, and male-sterile scion/male-sterile stock using the annual tester SLC 03 CMS and its pollinator SLC 03 as parent material. In addition several grafts were made of fertile SLC 129 and inbred CT 5 lines on good biennial CMS stocks.

Methods of procedures used in these grafting studies were given in the 1963 Research Report p. 77. The results obtained for the G_0 (scion) and G_1 (first self) generation for the annual sugarbeets were also presented in 1963. Data for the G_2 generation of the annual grafts and the G_0 and G_1 generations of the biennial grafts will be given in this report.

Several new grafts were made during the winter of 1963-64 to test transmission by a new grafting technique and at the same time incorporate other lines of possible genetic diversity into the study. A description of these lines is given in Table 1.

In all the more recent grafts, SLC 03 CMS was used as the stock parent. When these plants were about 3 weeks old, the root was split down with a razor blade 1/4 inch from the crown. The seedling used as a scion was trimmed to wedge shape and inserted into the stock so that the crown tissue of the scion and stock were parallel to one another. A woman's hair clip was placed across the graft and left until union occurred. The red and yellow hypocotyl color served as a marker of the scion in most cases. Leaves of the rr hypocotyl scions were marked with India ink to certify the grafted segment.

The degree of fertility of each plant was determined by microscopic examination of stained pollen grains at anthesis of the first flowers on the terminal branch of the seedstalk.

Table 1 - Description of Lines Used in Grafts Made in 1963-64

Current no.	Description
M 3579-5	61-81393 Deming inbred 862-yellow root
92.592.1	S ₇ generation bbRR inbred CT 5 line
94414	Milpitas annual Bb R ^t R
94602.1	Line derived from CT 9 BBrr S ₃ generation
94625	S ₆ generation BBRR old CTR line
14460	SLC 03 BBrr
14460HO	SLC 03 CMS BBrr

Results and Discussion

1962-63 Annual grafts

The fertility of SLC 03 annual grafts in the G_2 generation is shown in table 2. The data bears out the same conclusion as was evident in the G_1 generation (Table 4 p. 82, 1963 Research Report). There was a wide range (10-100%) in stainable pollen with a high average fertility (84%); however, no male-sterile segregates were obtained. Phenotypic variation in sterility between flowers or branches of a seedstalk was not observed. The selfed progeny of grafts on CMS stocks remained equal in fertility, if not better than those descendants of SLC 03 grafted on fertile stocks.

Seed production of the SLC 03 grafted lines (Table 3) showed similar trends to those found for the pollen fertility observations. There was little difference between the range in seed production of selfed parental plants and later generation progeny seed. The G_1 plants tended to average less seed than their respective G_0 forebears, but this was probably due to the size of the bagged seedstalk rather than to differential fertility.

Fertility readings of backcrosses to male-sterile SLC 03 grafted lines are shown in Table 4. Five lines of a male-sterile scion grown on a male-sterile stock were crossed with the pollinator SLC 03 and produced 100% male-sterile progeny. Male-sterile scions on fertile stocks crossed back to SLC 03 produced all male-sterile progeny. Likewise, 7 lines of grafts of fertile scions grown on male-sterile stocks and crossed back to the male-sterile parent SLC 03 CMS produced 100% steriles. In all cases there were no differences between these backcross progenies and the progeny resulting from a cross of the male-sterile SLC 03 and its "0" type pollinator shown in the last line of the table.

1962-63 - Biennial grafts

The fertility of plug grafts made with biennial lines CT 5 and SLC 129 is shown in Table 5. The data represent a cross section of the total number of grafts that were made. In most cases there was little difference between the fertility of the pollen parent and the grafted scion. A few lines showed a marked reduction in stainable pollen, however; none of the scions became completely male sterile.

Eighteen G_1 lines with CT 5 and 17 lines with SLC 129 have been evaluated to date for percent fertility. Twenty-seven of these lines showed segregates for male sterility (Table 6); however, we cannot be certain that any of these steriles are of the cytoplasmic type. Practically all of the biennial pollinator lines available from Salt Lake stock carry the Mendelian male-sterile gene. Selfed progeny of the parental CT 5 and SLC 129 plants indicated that most of them

Table 2 - Pollen Fertility of SLC 03 Grafts in the G₂ Generation

Current no.	No. lines	Avg. no. plants per line	Pollen fertility ^{1/}	
			Range	Mean
<u>SLC 03 Scion / SLC 03 Stock</u>				
G 4514	5	43	10-100	79
G 4515	2	41	20-100	83
G 4516	6	31	10-100	82
G 4517	5	27	10-100	82
<u>SLC 03 Scion / SLC 03 CMS Stock</u>				
G 4501	5	20	60-90	82
G 4502	6	24	50-90	86
G 4503	6	25	50-100	85
G 4504	6	27	50-100	86
G 4505	6	29	50-100	86
G 4506	5	25	50-100	87
G 4507	5	34	50-100	85
G 4508	6	28	30-100	84
G 4509	5	32	10-100	83
G 4510	5	25	20-100	85
G 4511	5	31	30-100	83
G 4512	5	32	20-100	84
G 4513	5	26	30-100	81

^{1/} Percent fertility based on microscopic determination of acetocarmine stained pollen.

Table 3 - Seed Production of Self-Pollinated SLC 03, G₀ and G₁ Generation Progeny

SLC 03 plant	Number seedballs	G ₁ gen. seed no.	Number seedballs	G ₂ gen. seed no.	No. G ₁ plants	Avg. no. seedballs
SLC 03 scion / SLC 03 stock						
303-1	65	3502	15	4514	5	60
303-2	50	3503	22	4515	2	103
303-3	18	3504	90	4516	8	53
303-4	208	3505	48	4517	8	34
SLC 03 scion / SLC 03 CMS stock						
303-5	58	3281	96	4501	10	72
303-8	273	3282	70	4502	10	57
303-12	46	3283	166	4503	10	27
		3284	198	4504	9	35
		3285	235	4505	11	65
		3286	28	4506	8	32
		3287	31	4507	10	66
		3288	66	4508	10	43
		3289	105	4509	9	69
		3290	88	4510	10	51
		3291	19	4511	10	49
		3292	133	4512	10	76
		3293	68	4513	9	70

Table 4 - Fertility Reading for Backcrosses of Grafts From SLC 03 Lines

Cross	No. Lines	Avg. No. Plants per line	Percent	
			MS	F
MS scion X F MS stock	5	24	100	0
MS scion X F F stock	3	32	100	0
MS X F scion MS stock	7	81	100	0
MS X F	2	42	100	0

Table 5 - Fertility of CT 5 and SLC 129 Parental Lines and G₀ (scion) Generation Grafts

Plant	Pollinator % fertile ¹ / pollen	G ₀ Generation (scion) % fertile pollen		
<u>CT 5 Grafts</u>				
		<u>1114</u>	<u>1122</u>	<u>1124</u>
994	90	---	80	80
995	80	75	---	---
1009	80	20	---	---
1010	80	60	80	---
1016	90	70	---	---
1047	90	---	25	80
1057	90	---	80	95
1068	90	---	90	80
1073	85	---	90	---
1085	90	90	70	---
1094	80	95	70	---
1103	90	90	90	80
<u>SLC 129 Grafts</u>				
1156	80	---	80	80
1170	90	80	---	90
1174	90	90	90	50
1176	90	---	20	60
1225	85	---	---	90
1268	30	70	---	80

¹/ Percent fertility based on microscopic determination of acetocarmine stained pollen.

Table 6 - Fertility Readings of Biennial Grafts in the G₁ Generation

Current no.	Fertility Distribution			Average % fertility	Genotype ^{1/} of parent scion
	MS	PF	F		
<u>CT 5 Grafts</u>					
G 3201	6	5	24	63	Aa
G 3206	1	0	2	60	Aa
G 3208	2	0	10	72	Aa
G 3209	0	0	3	90	
G 3213	3	0	4	51	Aa
G 3214	3	0	1	23	Aa
G 3218	5	0	10	58	Aa
G 3220	3	1	14	73	Aa
G 3222	4	0	9	62	
G 3223	1	0	5	85	Aa
G 3226	3	1	7	58	Aa
G 3230	1	1	19	83	Aa
G 3231	1	1	22	83	Aa
G 3234	5	0	16	67	
G 3235	2	0	19	81	Aa
G 3236	2	1	9	69	
G 3237	7	1	13	57	
G 3299	4	0	0	0	
<u>SLC 129 Grafts</u>					
G 3240	0	2	4	77	Aa
G 3242	0	1	12	87	AA
G 3244	0	0	3	87	Aa
G 3245	2	0	2	48	Aa
G 3249	0	0	3	90	Aa
G 3251	8	0	18	61	
G 3252	2	0	5	64	Aa
G 3253	23	3	40	56	
G 3255	6	0	6	45	
G 3256	2	0	11	76	Aa
G 3260	4	0	5	50	
G 3262	0	2	28	85	AA
G 3269	4	2	11	62	Aa
G 3274	2	0	3	52	
G 3276	0	3	11	81	AA
G 3278	0	0	4	90	Aa
G 3280	10	6	13	48	Aa

^{1/} Genotype with reference to Mendelian male sterility (a₁ gene) determined by fertility of selfed progenies of parental plants tested as source of scion.

were segregating for Mendelian male sterility. Three plants of SLC 129 were homzygous AA, and in each case there were no male-sterile segregates in the G_1 progeny.

Nine male-sterile G_1 segregates from CT 5 and three from SLC 129 were crossed to the annual SLC 03 pollinator, and progenies were evaluated in the greenhouse this past fall to determine the nature of their sterility. Although the populations of these progenies were small (Table 7), an interesting observation was made. All of the crosses from SLC 129 source, and five from CT 5 gave the expected results for Mendelian male sterility, i.e., 100% fertile plants. Four lines from CT 5 grafts, however, produced completely male-sterile progeny, as would be expected for a cross of CMS X O type pollinator. Anthers of these lines exhibited a pale-yellow color, but there was an absence of stainable pollen. Further study is planned to varify whether these segregates are truly CMS or if they can be explained by the environment under which the plants were classified.

1963-64 Grafts:

The fertility readings of the G_o (scion) generation of grafts made in 1963-64 are given in Table 8. All lines showed autonomy with one exception. A single scion of the Milpitas annual 94414 was male sterile.

Table 7 - Fertility Readings of Male-Sterile Segregates From
CT 5 and SLC 129 Scions Crossed to SLC 03

Current no.	<u>Fertility distribution</u>			Mean % fertility
	MS	PF	F	
<u>CT 5 MS X SLC 03</u>				
GB 4101	17	1	0	3
GB 4104	0	0	2	90
GB 4105	0	0	3	90
GB 4107	0	0	4	90
GB 4108	9	0	0	0
GB 41013	0	0	2	90
GB 41015	6	0	0	0
GB 41021	0	0	10	90
GB 41048	6	0	0	0
<u>SLC 129 MS X SLC 03</u>				
GB 41022	0	0	6	90
GB 41025	0	0	28	90
GB 41028	0	0	1	90

Table 8 - Fertility Readings of G₀ (Scion) Generation
of Grafts Made in 1963-64

Scion	Stock	Fertility distribution			Total plants	Avg. percent fertility
		MS	PF	F		
<u>F</u>	<u>MS</u>					
M 3579-5	03CMS	0	0	2	2	90
94414	03CMS	1	4	13	18	73
94602.1	03CMS	0	7	23	30	71
94625	03CMS	0	0	9	9	90
SLC 03	03CMS	0	3	44	47	85
<u>MS</u>	<u>F</u>					
SLC 03 CMS	SLC 03	15	0	0	15	0

Association of Cytoplasmic and Mendelian Male Sterility

By: J. C. Theurer and C. H. Smith

Studies were initiated in 1963 to further elucidate the peculiar relationships noted by Dr. V. F. Owen wherein certain cytoplasmic male steriles apparently segregated with Mendelian ratios and vice versa (1958 Sugarbeet Research Report, p. 35). Lines of sugarbeets thought to be carrying the a_2 Mendelian sterility gene, or a new undetermined type of sterility, were also planted to determine their inheritance.

Materials and Methods

A description of the sugarbeet lines used in these studies is given in table 1. Stecklings of each line were planted in the spring of 1963 in a greenhouse maintained at 70-80°F. At Anthesis pollen from the first 5-10 open flowers were collected, stained with acetocarmine, and observed microscopically. The fertility of each plant was determined with 70% stainable pollen being the dividing line between PF and F classes. All fertile plants were bagged and allowed to self pollinate. Crosses were made of representative male sterile segregates of each line with SLC 128, SLC 128aa, and SLC 03. In addition a few fertile plants of each line were crossed to the annual tester SLC 03 CMS. Crosses with the annual beets were classified for fertility in the greenhouse during the fall and spring of 1963-64. Selfed progenies of three of the biennial lines were evaluated in the greenhouse in the late spring of 1964, and those of four others were read in the field this past summer. Results to date are reported herein. Crosses with SLC 128, and SLC 128aa, and other selfed progenies have not been classified for fertility as yet.

Results and Discussion

The segregation for fertility has been grouped into 4 units and is presented in table 2. The 4 lines 361, 362, 363, 364, shown in section A varied considerably. Two lines (361, 363) were almost 0-type when indexed with the annual male-sterile tester SLC 03 CMS. The other line tested (363) was not. Partial fertiles were produced when 363 and 364 male steriles were crossed with SLC 03, indicating that the cytoplasm of these lines may differ from that of SLC 03 CMS. The evidence from selfed progenies would also favor cytoplasmic rather than genetic type of sterility. Inasmuch as Dr. Owen regarded these lines as Mendelian steriles (a_2a_2), it poses a question. Do genetic male steriles segregate for semi-sterility? It has been concluded in the past that they did not. However, classification was made on the basis of visual observation rather than by microscopic determination. Perhaps semi-steriles were not recognized in genetic male-sterile populations because they shed a fair amount of pollen. Additional investigation will be needed to clarify this point.

Table 1 - Lines used to study association of cytoplasmic and Mendelian male sterility.

Line No.	Description
361 362 363 364	These 4 lines are progeny of SL 5090 a derivative of CT 9 which were thought to be carrying the a_2a_2 Mendelian male-sterile gene.
365 367 377	These 3 lines are progeny of SL 7125, a CMS population that segregated 50% fertile and 50% sterile.
372 372A	Lines derived from SL 7215, a Mendelian male sterile that appeared to change to CMS.
373 374 375 376 383 383A	Lines from various sources which were classified by Dr. Owen as either new Mendelian or new cytoplasmic male steriles.

Table 2 - Fertility readings of progeny from questionable aa or CMS male sterility.

Section A			
Line No.	FERTILITY READING		
	MS	PF ¹ /	F ¹ /
361	0	5	5
362	4	2	9
363	3	9	3
364	3	10	2
SLC 03 CMS X 361	48	1	0
SLC 03 CMS X 362	53	15	0
SLC 03 CMS X 363	45	1	0
363 MS X SLC 03	25	14	0
364 MS X SLC 03	25	2	0
361 Semi ⊗	12	34	67
362 Semi ⊗	33	131	49
363 Semi ⊗	26	47	18
364 Semi ⊗	43	117	11
Section B			
365	6	2	7
367	4	8	3
377	7	0	8
SLC 03 CMS X 365	62	0	0
365 X SLC 03	0	22	43
367 X SLC 03	0	7	46
365 Semi ⊗	5	55	25
367 Semi ⊗	8	19	33
377 Semi ⊗	0	32	32
Section C			
372	15	0	0
372A	15	0	0
372 X SLC 05	60	8	0
Section D			
373	11	0	0
374	3	0	0
374 X SLC 03	40	7	0
375 CMS	0	1	13
SLC 03 CMS X 375	57	0	0
376	3	2	9
SLC 03 CMS X 376	85	0	0
383	4	4	0
383A	5	3	7
383A MS X SLC 03	8	2	0
SLC 03 CMS X 383A	8	3	2

¹/ PF = 2%-65%, F 70%-90% Stainable pollen.

Parental lines 365, 367, 377 (table 2 section B) segregated so as to make it difficult to discern whether they carry strictly genetic or cytoplasmic sterility determinants. Based upon the cross of 365 X SLC 03, these lines appear to be O type. Results of crossing male-sterile segregates of lines 365 and 367 with SLC 03 were those expected for Mendelian type of male sterility, since SLC 03 is O-type and doesn't carry aa genes. Selfed progeny segregation further substantiates Mendelian sterility for these lines if one assumes that normal fertile plants produce as little as 50% stainable pollen (all plants classified semi-sterile in these crosses had between 50-60% stainable pollen). An alternative could be that this particular sterility is governed by more than a single pair of genetic factors. This seems plausible, since Dr. Owen noted several years ago that segregation of certain crosses made with a_2 Mendelian sterility could not be explained on the basis of a single "gene."

Lines 372 and 372A (table 2 section C) are definitely of the cytoplasmic type. The one cross with SLC 03 suggests there may be different cytoplasms in 372 and SLC 03 CMS. This particular male sterile was included in several isolation plots this past summer. All 90 seedlings planted in these plots were white-anther male steriles.

Segregation in the other lines which gave male-sterile progeny of undetermined type are given in section D of table 2. Lines 373 and 374 are probably cytoplasmic steriles and line 375 failed to produce any male-sterile segregates. The type of sterility in the other three lines is still questionable.

Crosses with SLC 128 + a_1 , or other lines carrying the a_1 gene, will probably further clarify the inheritance of these male-sterile lines.

Restorer Genes and Cytoplasmic Male Sterility

J. C. Theurer and G. K. Ryser

The program initiated in 1962 to isolate lines carrying pollen-restorer genes for use in inheritance studies of male sterility was continued again this year. The most fertile plants derived from the restorer line L 11120 (SLC 03 CMS X Ruby Queen table beet), reported in the 1962 annual report, were selected and selfed for two generations. The most fertile S_2 plants were also crossed back to the annual tester SLC 03 CMS. Segregation for male fertility in each generation was determined by microscopic readings of acetocarmine stained pollen. Crosses were also made of the most fertile segregates and three biennial male-sterile lines.

In addition to continuing selection on the restorer line, the variety from Ruby Queen, five other non-0-type lines were crossed to the annual tester. The F_1 progenies were grown and read for fertility. The S_1 generation of two other lines in which Dr. Owen found restorer genes were classified for fertility.

Results

Segregation for fertility in the three best restorer lines derived from crosses involving the annual tester SLC 03 CMS and the Ruby Queen variety of table beet are shown in Table 1. Selection of fertile (over 90% stainable pollen) plants in the S_1 resulted in an increase in the number of fertile segregates in each population in the S_2 . However, self-pollinated fertile plants still produced male-sterile segregates. In backcrosses, there were no male-sterile segregates, which agrees with the original F_1 cross. The various MS:F ratios and the fact that fertile segregates vary so much in stainable pollen indicates that the inheritance is considerably more complex than the original one-gene hypothesis proposed in 1962. It appears also that it might prove difficult to isolate a strong homozygous restorer line from this material wherein all plants are completely fertile.

The fertility readings of the 5 non-0-type lines crossed with the annual SLC 03 CMS are given in Table 2. Only line 441.20.3 showed possibilities of carrying strong restorer genes. Some of these lines have been crossed with biennial male steriles to determine if there is any difference in the MS:F segregation ratios with different male steriles.

S_1 generations of two lines scored by Dr. Owen as carriers of restorer genes segregated quite differently (Table 3). One line had about 50% male-sterile and 50% semi-sterile plants. The other one segregated 78% male sterile. Neither population had a fertile plant (over 75% stainable pollen) in the progeny.

Table 1 - Segregation for Fertility in Three SLC 03 CMS
X Ruby Queen Selections.

Current No.	Gen.	Description		Fertility reading			Ratio ^{2/} MS:F
				MS	PF	F ^{1/}	
25101	S ₁	11119-1	⊗	27	83	24	1:4
35101-18	S ₂	25101-18	⊗	6	41	8	1:8
RB 31223	S ₂ ^b ₁	BMS X 25101-18		0	38	3	0:1
25111	S ₁	11120-4	⊗	34	27	15	1:1
35111-60	S ₂	25111-60	⊗	6	51	6	1:9
RB 31226	S ₂ ^b ₁	BMS X 25111-9		0	9	17	0:1
RB 31228	S ₂ ^b ₁	BMS X 25111-60		0	1	26	0:1
25004	S ₁	11101-5	⊗	57	49	13	1:1
35004	S ₂	25004-2		2	56	1	1:29
RB 31193	S ₂ ^b ₁	BMS X 25004-1		0	8	17	0:1

^{1/} Plants scored 75% or better stainable pollen.

^{2/} Partial fertile + fertile classes.

Table 2 - Fertility Readings for 5 non-0 Type
Lines Crossed to SLC 03 CMS.

Current No.	Description	No. crosses	Fertility reading			Ratio ^{1/} MS:F
			MS	PF	F	
RB 31258etc.	BMS X SP 561-0	59	541	252	145	1:1
RB 31266etc.	BMS X 0524	2	86	8	0	11:1
RB 31256etc.	BMS X 2910	6	62	56	4	1:1
RB 31257etc.	BMS X 2911	8	108	86	1	1:1
RB 3103etc.	BMS X 441.20.3	21	5	287	280	1:113

^{1/} Partial fertile + fertile classes.

Table 3 - Fertility Readings of 2 Possible
Restorer Lines in the S₁ Generation

Current No.	Description		Fertility reading			Ratio ^{1/} MS:F
			MS	PS	F	
11103 etc.	92.1.1H1-1 etc	⊗	337	93	0	4:1
92.04H1-156 etc	92.04H1-1 etc	⊗	79	89		1:1

^{1/} Partial fertile + fertile classes.

VARIETY TESTS, LOGAN, UTAH, 1964

By G. K. Ryser

SOIL TYPE: Silty clay loam

PREVIOUS CROPS: 1963 Safflower; 1960-1962 Alfalfa

PLANTED: May 1, 1964

THINNED: June 6, 1964

IRRIGATIONS: Weekly schedule starting July 3, 1964

CURLY TOP: Very slight symptoms were noted on the variety tests at Logan, but most of the varieties in test 2 were planted in the curly top testing field at Thatcher by Albert M. Murphy and curly top data given in test 2 came from this source.

HARVESTED: October 12-16, 1964

Tops were removed with a rotoblator and scalped with tractor-mounted scalping tools, supplemented by long-handled hoe trimming to assure a complete topping job. Beets in plots were counted (after scalping) before lifting with the harvester. Ten-beet samples were obtained at random from each of the two center rows of each four-row plot for sugar analysis, and all beets in the two center rows were weighed to determine root yield.

Experimental Design: Test 1 consisted of 49 varieties planted as a 7 X 7 balance lattice with 8 replications. The three high varieties of last year (1101, 1114, and 9140) were included in the test as checks.

Test 2 was a 6 X 6 triple lattice repeated once for a total of 6 replications. The 36 varieties were made up of the hybrid 1114 as check and hybrid seed from 5 male-sterile lines grown at 7 different isolations having nearly the same pollen source, which was 3 individual S₂ sister lines from the 630 Ovana hybrid (US 35aa X (US 35 X Ovana) X CT 8).

Plots were four rows wide 22 inches apart with a harvested plot length of 28 feet.

Both tests were analyzed as lattices and means reported are adjusted means.

The variety tests in 1964 were conducted mainly to evaluate the merits of Ovana, Udydz, and Janasz lines in hybrid combinations with various CMS lines.

TEST 1

Thirty-three varieties in this test consisted of various CMS females with pollen from three S_2 sister lines derived from the ovana hybrid SL 630 (US 35/2 X CT 5) X CT 8). Seed of these varieties was produced in eight plots with different sister lines present at each location. The Udycz pollinator, a parent of varieties 31971, 31943, 31980, 31967, and 311002, was received from Dr. Jan Kostechi through Dewey Stewart in 1959. Inbreds CT5, CT8, and CT9, were the other lines used as pollinators. The two top varieties in the 1962 and 1963 tests, 1101 and 1114, (Tables 1,2,3, p. 75-77 1962 report - Table 1, p. 94 1963 report) were used in 1964 as checks. The check variety 9140, used in the 1962 and 1963 tests, was also included in this year's tests; but stands of this variety were poor, making comparisons of little importance.

The first four listed hybrids (311004-9), (31994-1), (31971), and (31978-1) were all given good root shape ratings.

The ten varieties with the highest gross sugar per acre are not significantly different at the 5% point until the last variety of the ten (31970-9) is compared to the first (311004-9). The significant difference between the best check variety, 1114, and 311004-9 in gross sugar could be due to the low tonnage year, without increase in the sucrose percentage of the high yielding checks of 1962 and 1963.

The high tonnage variety 311009-9 is primarily of Mangel origin, the female being a red-anther beet obtained from Dr. LeRoy Powers. The hybrid has white, red, or yellow colored roots with a very smooth, somewhat typical Mangel shape. This variety would be expected to be "yield type." Differences in tonnage of the first eight ranked lines were non-significant. Variety 311009-9 was the only variety that had a significantly better tonnage than the check varieties 1114 and 1101. The sucrose percent (14.7) of this variety (311009-9) was among the lowest in the test but was equal to that of the checks.

The significant sucrose percent of 16.1 for variety 31971 and 16.0 for variety 311004-9 indicated superiority of these lines over all varieties of the test. Variety 311004-9 was made up of SLC 35 CMS, which carries Janasz cytoplasm, and S_2 pollinator lines from the SL 630 ovana hybrid. Janasz was previously reported by Dr. V. F. Savitsky (1962 report, p. 232) to be high in sucrose. In combination with hybrid SL 630 it produced a significant sucrose yield in the test. Variety 31971 has as the CMS female parent, SLC 129 times a group of selected nematode numbers derived from material sent to us in 1956 by American Crystal Sugar Company. Udycz was the pollen parent for this hybrid. Undoubtedly the good sucrose and tonnage yield in these two numbers were due to good specific combining ability for this characteristic, showing the importance of diversified germ plasm for good hybrid vigor.

VARIETY TEST, NORTH FARM, LOGAN, UTAH, 1964
49 varieties, 8 replications of each variety
BALANCED LATTICE

BALANCED LATTICE		ADJUSTED MEANS				TEST 1			
Variety No.	Description	Acre	Yield	Percent Sugar	PPM			Beets 100	Impurity Index
		Gross Sugar	Tons Beets		Amino N	Na	K		
311004-9	SLC 35 X 630 S ₂	5986	18.5	16.0	347	199	1405	98	487
311009-9	59-9807-12 X 630 S ₂	5861	19.7	14.7	325	257	1633	100	565
31994-1	SLC 129 X 630 S ₂	5716	18.5	15.2	300	216	1306	96	462
31971	(SLC 129 X Nema A) X Udyca	5718	17.7	16.1	339	151	1541	79	487
31998-1	NB 1 X 630 S ₂	5555	18.0	15.3	283	189	1347	82	452
31996-9	CT 9 X 630 S ₂	5536	18.0	15.3	302	168	1415	74	467
31955-9	(AI 1 X 10 X SLC 129) X 630 S ₂	5476	17.8	15.3	325	200	1397	95	490
31968-9	(SLC 129 X Nema A) X 630 S ₂	5432	18.0	14.9	361	220	1646	91	573
311004-1	SLC 35 X 630 S ₂	5304	17.3	15.1	332	225	1373	101	506
31960-9	(AI 1 X SLC 130) X 630 S ₂	5275	17.2	15.2	343	208	1367	96	499
31956-9	(AI 1 X SLC 129) X 630 S ₂	5266	16.5	15.8	272	200	1403	94	442
31993-8	SLC 129 X 630 S ₂	5262	17.1	15.3	322	172	1470	92	508
1114	9132 X CT 5	5178	17.2	14.9	295	186	1260	95	457
31949-1	(AI 1 X 10 X SLC 129) X 630 S ₂	5159	16.7	15.3	311	186	1371	93	475
1101	(SLC 129 X CT 5) X (630 X CT 5)	5110	17.3	14.7	308	217	1272	91	479
33119-9	SLC 129 X 630 S ₂	5113	17.1	14.9	330	176	1413	79	501
31935-6	(SLC 133 X SLC 131) X 630 S ₂	5098	16.6	15.2	315	216	1350	91	481
31965-9	0189 X 630 S ₂	5080	16.2	15.6	388	140	1372	88	503
31976-9	(Ovana MS X mm + a) X 630 S ₂	5053	17.1	14.6	380	237	1535	103	586
31939-9	(SLC 133 X CT 5 MM) X 630 S ₂	5030	16.6	15.1	346	176	1324	95	493
31977-9	(AI 1 X SLC 129) X 630 S ₂	5020	16.4	15.2	371	159	1441	85	523
31993-5	SLC 129 X 630 S ₂	5020	16.7	14.9	268	217	1192	87	431
31943	(SLC 133 X CT 5) X Udyca	4927	15.4	15.8	258	165	1172	92	385
31980	(9132 X CT 5) X Udyca	4913	15.3	15.9	229	226	1385	87	414
31972-4	(SLC 129 X Nema B) X 630 S ₂	4869	16.3	14.7	361	225	1493	88	563
31949-9	AI 1 X 12 X 630 S ₂	4828	16.4	14.5	308	174	1330	104	490
9140	7121 X CT 5	4758	15.9	14.9	328	182	1355	76	491
31942	(SLC 133 X CT 5) X CT 5	4700	15.9	14.6	258	235	1277	85	454
31940-9	do X 630 S ₂	4704	15.4	15.3	322	173	1326	101	460
31956-1	AI 1 X 630 S ₂	4681	15.4	15.0	298	182	1366	91	469
311006-1	SLC 91 (4n) X CT 8	4616	14.9	15.3	251	254	1421	78	458
31947-1	0167 X 630 S ₂	4608	15.3	14.9	303	209	1260	94	468
31944-6	(9132 X line 289) X 630 S ₂	4547	14.8	15.4	420	151	1299	82	522
31945-9	(SLC 130 X line 289) X 630 S ₂	4352	14.0	15.4	335	169	1197	98	457
31952-9	(AI 1 X 12 X 129) X 630 S ₂	4334	14.5	14.8	319	176	1300	91	476
31946	(SLC 129 X SLC 130) X CT 5	4327	14.5	14.8	351	270	1159	84	501
31931-5	SLC 126 X 630 S ₂	4314	14.5	14.7	332	200	1491	73	536
31955-1	(AI 1 X 10 X SLC 129) X CT 8	4297	14.7	14.5	339	164	1444	71	526
311003-3	mm X CT 8 (MS X CT 8)	4271	13.8	15.5	307	254	1431	77	490
31977-2	(9132 X CT 5) X CT 8	4255	14.4	14.7	339	179	1289	94	497
31987-2	(9132 X line 289) X CT 8	4202	14.4	14.3	294	221	1315	75	493
31967	0189 X Udyca	4199	13.0	15.9	256	211	1451	73	439
31947-9	0167 X 630 S ₂	4103	13.8	14.7	331	162	1301	90	489
31937-3	SP 557 X 630 S ₂	3936	13.1	14.9	375	176	1365	71	524
31979	(9132 X CT 5) X CT 5	3914	13.7	14.0	265	250	1328	74	499
31955-5	(AI 1 X 10 X SLC 129) X 630 S ₂	3926	11.8	14.7	345	138	1174	90	473
31962	(AI 1 X SLC 130) X CT 5	3472	12.4	13.8	213	275	1234	65	450
33122-5	CT 8 aa X 630 S ₂	3218	10.5	15.1	475	157	1191	82	553
311002	7125 X Udyca	2748	9.5	14.4	362	234	1680	39	603
General Mean of all Varieties		4752	15.60	15.05	322	198	1365		491
S. E. of Mean		252	0.74	0.19	23	15	50		23
Sig. Difference 5%		704	2.05	0.53	64	41	140		64
Coefficient of Variation %		15.01	13.33	3.59	20.04	21.18	10.37		13.39
Calculated F Values		7.39**	8.00**	6.78**	4.35**	5.44**	5.67**		3.45**

** Exceeds the 1% point of significance (F=1.58)

1/ Modified Carruthers Impurity Index, see narrative for formula

The Udycz pollinator produced good sucrose percentage with all CMS females tested, with non-significant differences between the females. Variety 311002, which also has Udycz as a parent, is not considered a fair comparison because of the very poor stand of this line, resulting in only large beets being sampled.

The hybrid 31976-9 (Ovana MS X SL 630 S₂) was poor in sucrose but not significantly different than the best check variety. This combination is of interest because of the ovana parentage.

The only triploid in the test, 311006-1, placed low in rank mainly due to poor tons per acre yield. The sucrose percent was about average. The pollinator of this hybrid was CT 8, which was selected for high sugar but is known to have poor combining ability for tonnage factors.

The impurity variables N, Na, and K, together with sucrose, were combined into an impurity index using a modified Carruthers' formula.* The variety 31998-1 (NB 1 X 630 S₂) was the only one of the first ten varieties ranked according to gross sugar that placed in the first ten when ranked by low impurity index. This variety also placed in the first ten when ranked by low "N", which probably accounts for its place in the impurity index values.

TEST 2

Of the top yielding ten varieties in Gross Sugar and tons per acre, three had 31968 (SLC 129 X Nema A) as the CMS female parent, three had 31976 (Ovana MS X mm +a), three had 31939 (7121 X CT 5), and one had 31940 (7121 X CT 5A) (Table 1). Seed of these varieties was produced at six of the seven isolations or locations.

A study of the 630 S₂ sister lines at each location revealed that sister lines 2515 and 2516 were the best for high yield in tons per acre, however, 31968-4 with sister line 2514 was an exception.

The difference between acre yield of the five CMS females was due to the comparatively low average yield of varieties having 31945 (SLC 130 X line 289) as a parent (Table 2).

Hybrids having the CMS female, 31976 (Ovana MS X mm +a), produced the lowest average sucrose percent. Differences between means of grouped females were due to this line (Table 2). There was little difference between sucrose averages when grouped as to location.

The variety combinations of this test have comparatively large average differences in impurity factors due to CMS female differences.

* See Myron Stout's Impurity Index Values for further explanation, page 90.

VARIETY TEST, NORTH FARM, LOGAN, UTAH, 1964

36 varieties, 6 replications
Repeated triple lattice

Variety	Description	ACRE YIELD		Sucrose	Curly Top ¹ / Aug. 21	Test 2			Table 1	
		Gross Sugar	Tons Acre			PPM			Beets 100	Impurity Index
						N	Na	K		
31939-9	(7121 X CT5) X 630 S ₂	6,596	21.3	15.5	38.2	324	179	1210	96	448
-8	do do	6,421	20.8	15.5	20.8	236	181	1216	106	453
-3	do do	6,367	21.0	15.1	18.7	349	176	1334	100	497
-1	do do	6,356	20.7	15.3	28.8	356	224	1267	88	492
-5	do do	6,314	20.5	15.3	23.4	393	168	1298	97	508
-6	do do	5,970	19.0	15.6	37.5	385	134	1176	95	463
-4	do do	4,873	17.2	14.0	20.0	332	261	1108	94	514
31940-1	(7121 X CT5A) X 630 S ₂	6,631	21.7	15.3	27.3	327	244	1209	103	470
-5	do do	6,326	20.7	15.0	13.4	417	215	1240	108	530
-3	do do	6,131	20.8	14.8	34.3	358	206	1201	95	499
-8	do do	6,050	20.8	15.6	28.8	339	201	1273	106	580
-9	do do	5,903	19.7	15.0	30.3	374	210	1260	93	505
-4	do do	5,883	19.8	14.7	21.5	256	238	1139	94	425
-7	do do	5,829	19.7	14.8	27.4	455	212	1230	95	572
31945-1	(SLC130 X 289) X 630 S ₂	6,281	20.7	15.2	28.0	435	211	1114	101	525
-8	do do	5,945	19.3	15.3	40.4	456	209	1151	92	535
-9	do do	5,304	17.4	15.1	35.5	420	193	1055	91	498
-3	do do	5,291	17.2	15.4	31.5	410	162	1151	96	493
-5	do do	5,235	17.4	15.0	24.3	454	170	1078	94	525
-4	do do	5,232	17.3	14.9	31.0	424	155	1086	91	501
-7	do do	5,138	16.7	15.1	41.2	470	174	1100	91	533
31968-9	(SLC129XNemaA) X 630 S ₂	7,289	24.6	14.9	17.0	409	258	1593	109	604
-4	do do	6,939	22.8	15.1	40.6	353	221	1461	95	529
-7	do do	6,612	21.6	15.4	32.9	360	240	1430	90	530
-5	do do	6,558	21.6	15.1	35.9	372	223	1386	99	640
-3	do do	6,300	21.0	15.0	42.0	319	222	1382	104	497
-1	do do	5,960	19.3	15.2	11.8	352	208	1359	94	508
-8	do do	5,214	17.7	14.7	18.7	404	183	1449	88	567
31976-7	(OvanaMSXmm+a) X 630 S ₂	6,778	23.9	14.1	14.5	402	365	1470	94	644
-1	do do	6,580	21.9	15.0	29.3	386	293	1384	107	554
-3	do do	6,557	22.3	14.6	12.8	412	224	1378	106	574
-8	do do	5,742	20.2	14.1	-	416	311	1476	99	640
-9	do do	6,659	20.0	14.0	26.0	379	348	1381	104	607
-4	do do	5,630	19.7	14.0	18.9	384	332	1280	88	589
-5	do do	5,164	18.3	14.0	14.0	455	306	1255	98	626
Check 1114	9132 X CT 5	5,932	19.97	14.90	26.71	321	206	1158		458
General Means of all varieties		6,011	20.14	14.87		383	224	1271		529
S. E. of Adj. variety mean		278	0.87	0.28		22	18	48		33
Sig. Diff. 5%		786	2.47	0.79		63	52	137		94
Estimated F values*		3.75	5.60	4.71		5.12	10.40	7.70		4.51

¹/ Average of two replications from Thatcher test.

* Not corrected for adjusted means.

VARIETY TEST, NORTH FARM, TEST 2, LOGAN, UTAH, 1964

Means Grouped By Locations

Table 2

CMS Females	ACRE YIELD		Suc. %	N	PPM		Imp. Index	Curly Top %
	Gross Sugar	Tons Acre			Na	K		
(7121 X CT 5)	6,128	20.1	15.16	352	189	1230	482	26.77
(7121 X CT 5A)	6,095	20.5	14.89	361	218	1222	500	26.14
SLC130 X Line 289	5,490	18.0	15.15	438	182	1105	516	33.08
SLC129 X Nema A	6,410	21.2	15.05	367	222	1438	553	28.32
Ovana MS X mm +a	6,012	20.9	14.27	504	311	1375	605	19.25
Standard Error	124	1.23	.40	39	26	69	46	

Locations

1	6354	20.9	15.2	371	236	1265	510	25.04
3	6129	20.5	15.0	370	190	1289	512	27.86
4	5706	19.4	14.6	350	241	1215	511	26.40
5	5919	19.7	14.7	418	216	1251	566	22.14
7	6065	20.2	15.0	415	225	1283	549	30.7
8	5874	19.8	14.9	388	217	1313	539	27.18
9	6150	20.6	14.9	381	237	1300	532	29.4
Standard Error	130	1.29	.42	41	26	72	49	

Physiological Studies

Growth Chambers

By: Myron Stout

During the first half of 1964 considerable trouble was encountered with temperature control in the Percival growth chambers. Metallic contact points stuck and the temperature was reduced to near freezing quite frequently. The more expensive controls were finally replaced with mercoide controls, costing about one-tenth as much. They have proven to be reliable and apparently as accurate as the more expensive controls. Growth abnormalities were attributed to the frequent low temperatures. However, nutrition proved to be the major cause of the difficulty. Another problem that developed with the growth chambers has been due to high voltage which is supplied in the building. Incandescent lights burned out very frequently even after 130-volt globes were used. Voltages reported by three separate electricians on the 120-volt circuit in the growth chambers varied from 125 to 180 volts. The voltage was finally reduced at the substation, about 1/2 mile from the building, and since then our problems have been reduced.

The beets were grown in vermiculite in one-quart, square plastic refrigerator containers that were painted black on the outside and had drainage holes drilled in each side 1/2 to 1 inch from the bottom. The nutrient solution used was half-strength Hoagland solution, with the final dilution being made with tap water.

A separate nutritional test was run, using half-strength Hoagland solution with and without minor elements, and final dilutions were made with distilled vs. tap water. An additional 1 mg. per liter of iron was used in another variant of the test. Two varieties of sugar beets were used. Cobalt ammonium sulfate was added to the minor element solution. Kel 138 (6% Fe) was used as the source of iron and at the same iron concentration as that recommended by Hoagland.

Results and Conclusions

Deficiency symptoms developed rapidly in all treatments that received no minor elements - but more rapidly in those made up to final concentration with tap water. Boron-deficiency symptoms developed in some plants of all treatments. Iron was apparently lacking in all treatments except those that received one additional part per million of iron.

It is recommended that all half-strength Hoagland solutions used on sugar beets be modified to include minor elements at full strength and additional iron (1ppm) be added if final dilutions are made with high bicarbonate tap water such as that in Logan.

Impurity Index Values

Calculation of apparent purity of sugar beets by dividing the direct polarization by refractometric dry substance has been the principal method of assessing sugar beet quality for a long time. On second carbonation juice or later steps in factory processing this is a dependable and useful value, but for laboratory evaluation of single roots or for agronomic plot samples it has been notoriously unreliable. Some of the basic causes of errors in purity values are that some of the constituents in the analytical procedures on beets are left in the solutions analyzed but are removed in the factory process. Another factor is the 7.7 to 1 dilution of the material analyzed in the half-normal diffusion technique. This dilution can be compensated by using a 400 mm. tube in the saccharimeter, but the refractometer's precision is penalized. Other problems with the dipping refractometer are the intensity of color and dispersion of the light beam by colloids in some half-normal diffusates, which reduce the precision. Normal diffusates are even more difficult to read due to even greater color intensity and light dispersion. Differences in purity values are not large, and because the values are quotients between two separate determinations, the errors can have a compensatory or additive effect on purity values. Methods of clarification to simulate the factory process have been tedious, time consuming, and require considerable sample material, although they are far more reliable than the old method. The dilution during clarification also requires a second polarization of the clarified filtrate.

Carruthers, Oldfield and Teague^{1/2}, have shown a high correlation between second carbonation juice purity and an impurity value based on the summation of the nitrogenous, sodium and potassium impurities per 100 sugar.

$$\text{Impurity Value} = \frac{2.5K + 3.5Na + 10 \text{ Amino N} + \text{Betaine}}{\text{Percent Sugar}}$$

In this calculation the multiplying factors calculate the determined constituents to their probable original molecular weights without any assessment of differential effects on quality per unit weight of impurity.

Ellerton³ has shown a high correlation and nearly identical values between Amino nitrogen as determined by the method of Moore and Stein and that determined by the simpler and more rapid method of Stanek-Pavlas. Carruthers et al. state that the Stanek-Pavlas values were higher and more variable than those determined by the Moore and Stein method used in their calculation. On factory liquors and heated diffusates the Moore and Stein method is probably more reliable but it is difficult to fit into a routine analytical program for screening breeding material.

There are two apparent reasons for a higher weighting of amino

nitrogen in our calculations than that used by Carruthers: (1) Carruthers et al add the betaine in their formula for the calculation of impurity value. (2) High glutamine or other amide nitrogen compounds, not included in the amino nitrogen values, decompose during the boiling and leave an acid residue that requires the addition of soda ash to maintain alkalinity during processing. It would seem, therefore, that a factor higher than 10 for amino nitrogen might be justified in our calculations. However, until further research is conducted to find other impurities and more accurate factors for assessing the economic quality of sugar beets, the present impurity index calculation is far superior to the "guess and hope" method based on the same analytical determinations made at this station since 1952.

The present values are calculated as follows:

$$\text{Impurity Index} = \frac{10 \text{ amino N} + 3.5 \text{ Na} + 2.5 \text{ K}}{\text{sugar \% by direct polarization}}$$

The impurity index of 49 varieties in Agronomic test 1 show a high of 603 and a low of 385 with a difference of 64 being required for significance. In test 1 only four varieties were not significantly higher than the variety with the lowest impurity index.

Differences in impurity index values of about 2900 individual beets were much larger. Values ranged to as high as 1083 and as low as 153. This broad range offers a very wide choice in selection of quality. They probably compare with differences in apparent purity between 75 and 90 percent. This wide spectral range certainly does not imply that the differences are all genetic in character. A large part is undoubtedly due to differences in nutrition and/or environment. However, the impurity index value is reasonably close to the quality or extractable sugar from a given sugar beet. Improvements in genetic and agronomic uniformity will reduce variations in impurity index values and still improve its usefulness in selecting beets of superior genetic quality.

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- 1/ Carruthers, A, Oldfield, J. F. T. and Teague, H. J. 1962. Assessment of Beet Quality. Fifteenth Annual Technical Conference of the British Sugar Corporation. Limited.
 - 2/ Carruthers, A, and Oldfield, J. F. T. 1960. Methods for the assessment of Beet Quality. Comm. Internationale de Sucreerie.
 - 3/ Ellerton, Sydney: The Determination of Amino Nitrogen in Sugar Beet -- Mimeographed report. Bush Johnson Limited.

Photosynthesis and Respiration Rate Studies

Measurements of photosynthetic and respiration rates are apparently affected by a number of variables. The 1963 report indicated that foliar density or arrangement is responsible for rather wide variations in net accumulation rates. Further studies during this past year have shown that this factor is very critical in making close comparisons between plants subjected to other treatments. As sugarbeet plants grow more foliage, the net accumulation rate per decimeter of leaf area declines, due to partial shading of some of the leaves. Erect or procumbent foliage types are also subject to the same, energy per unit of leaf area, factors.

Plants kept in darkness for 16 hours had lower respiration and higher net accumulation rates than plants tested after several hours of illumination. There was little or no difference after two hours of illumination. For this reason plants under critical periodic testing were all subjected to the day cycle (light) at least four hours before testing.

Root respiration and/or solubility of CO_2 in the growth media contributes to the CO_2 economy of plants. To evaluate this factor, seven tests were run with food-wrap plastic bags (baggies), tightly tied around the crown of the beets, and with the same beets without the root and container incased in the bags. Respiration rates averaged 1.87 mg. $\text{CO}_2/\text{dm}/\text{hr}$ lower and net accumulation rates were 1.81 mg. $\text{CO}_2/\text{dm}/\text{hr}$ higher with the "Baggies", indicating that root respiration contributed this amount of CO_2 per hour on plants averaging 9.74 dm. of leaf area. "Baggies", although not completely impermeable to CO_2 , should be used in all measurements of photosynthesis and respiration unless root respiration is desired to be included. These plastic containers are convenient, inexpensive, and probably quite effective in preventing CO_2 exchange during short-term measurements.

Effect of Curly Top and Western Yellows Virus on Photosynthesis and Respiration Rates of Sugarbeets

By Myron Stout and C. L. Schneider

Two series of tests have been conducted in an attempt to relate curly top and Western yellows virus infection to photosynthesis and respiration rates of sugarbeets. Two varieties and three replications of each treatment were used in each test. The first test was discontinued when aphids were found on both check and inoculated beets. The young aphids or eggs had apparently gotten through the mesh of the cages. Finer mesh cloth was used--and young aphids were still found on leaves outside the cages. Still finer mesh cloth was used that apparently prevented escape of the aphids.

Clear-cut differences in the characteristic symptoms between healthy and inoculated beets have not developed. Foliar growth and the respiration and photosynthetic rates have not been consistently different.

It appears at this time that either infection has been erratic or the development of the usual symptoms has been masked by nutritional and/or controlled climatic conditions in the growth chambers.

Further measurements will be made on the same plants, using a different technique of foliar arrangement. Foliage will be removed to an amount that can be exposed at right angles to the light source; thus no leaves will be shadowed by others.

Studies on Pathogenic Strains of Curly Top Virus

C. L. Schneider

Introduction

Investigations at the Logan station have been directed towards determination and identification of pathogenic strains of curly top virus occurring in the intermountain region. Giddings' studies have shown that several strains of curly top virus, differing in virulence, occur in the United States (1). In our current studies emphasis has been placed on determination of individual strains of the virus that differ in pathogenicity on certain differential hosts. Curly top strains showing such pathogenic specialization might be of extreme importance in the development of curly top resistant sugarbeet lines.

Methods

Thirty-seven curly top cultures were isolated from infected plants taken from the field and from plants exposed in the greenhouse to viruliferous beet leafhoppers collected in desert breeding areas. Efforts were made to purify the cultures according to previously described methods in order to preclude the possibility of working with mixed virus strains (3). The methods of isolation tended to favor selection of the more virulent strains. The cultures were maintained in the greenhouse on plants of sugarbeet varieties US75 and US41.

The curly top reaction of the following plant hosts was determined in the greenhouse: sugarbeet lines SL68, US75 (moderately resistant in field); SL742 (very susceptible); tomato, line 193, Lycopersicon pimpinellifolium (included because of variation of reaction in field tests (2)); Capsella bursa-pastoris; and Turkish tobacco, var. Samsoun. Beet leafhoppers from nonviruliferous stocks were allowed to feed on leaves of curly top sugarbeets of each culture for approximately 7 days and were subsequently transferred to seedlings of the host species. Sugarbeet seedlings were each exposed to one leafhopper in a glass cage attached to a cotyledon; tomato, L. pimpinellifolium and C. bursa-pastoris seedlings were similarly exposed to two insects each. Each tobacco seedling, in a lamp chimney cage, was exposed to ten insects. Insects were removed after 7 days.

Six weeks after exposure to viruliferous leafhoppers, each plant was graded numerically according to degree of curly top damage from 0 (no symptoms) to 9 (plant dead).

Results and Conclusions

In table 1 is shown the range of curly top damage caused by the 37 curly top cultures on the 7 plant hosts. Differences among the host species in susceptibility to the curly top isolates are apparent. The virus isolates differed in degree of virulence on the different hosts. Turkish tobacco showed a much wider range of reaction to the virus isolates than did the other host species.

In table 2, the reaction of each host species to each of the curly top isolates is shown. It is apparent that reaction of tobacco to some of the isolates (i.e. A4D, A11B, B6A, B6D) was inconsistent with the reactions of the other host species.

Further studies are planned to determine the suitability of Turkish tobacco for identifying pathogenic races of curly top virus. It is proposed that any pathogenic races so identified be tested on sugarbeet lines used in the program of breeding curly top resistant varieties.

Literature Cited

1. Giddings, N. J. 1944. Additional strains of the sugar beet curly top virus. Jour. Agr. Res. 69(4):149-157.
2. Martin, Mark W. 1963. Responses of curly top - resistant Lycopersicon species to curly top exposure in different areas of the west. Pl. Dis. Reprtr. 47(2):121-125.
3. Schneider, C. L. 1963. Curly top disease investigations. Sugarbeet Research:102-109.

Table 1 - Frequency Distribution of 37 Curly Top Virus Isolates According To Degree of Virulence on 7 Plant Hosts in Greenhouse: Number of Isolates in Each Virulence Class

Host	Virulence Classes									
	0	0.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	
Sugarbeet, SL 68	-	-	-	3	20	13	1	-	-	
Sugarbeet, US 75	-	-	-	-	10	20	7	-	-	
Sugarbeet, SL 742	-	-	-	-	-	-	9	20	7	
Tomato, Line 193	-	-	-	-	1	11	16	8	1	
Lycopersicon pimpinellifolium	-	-	-	1	5	17	9	5	0	
Capsella bursa-pastoris	-	-	-	-	1	4	9	19	4	
Turkish tobacco	2	-	-	1	6	4	9	13	2	

Table 2 - Comparison of Virulence of 37 Curly Top Virus Isolates on Different Species of Test Plants^{a/}

Curly top virus isolates and source				Host species and their reaction ^{b/} to each curly top virus isolate						
				Sugarbeet			Tomato	Lycopersicon	Capsella	Turkish
				SL 68	US 75	SL 742	line 193	pimpinelli- folium	bursa- pastoris	tobacco
A1A	Thatcher, Utah, 1962			S	S	VS	S	S	VS	S
A1C	do do do			S	S	VS	S	S	VS	S
A3A	do do do			S	S	VS	S	S	VS	S
A3B	do do do			S	S	VS	S	S	S	VS
A4D	do do do			S	S	VS	S	S	S	R
A7A	do do do			S	S	VS	S	VS	S	S
A9C	do do do			S	S	VS	S	S	VS	S
A10A	do do do			S	S	VS	S	S	VS	R
A11B	do do do			S	S	VS	VS	VS	VS	R
A12A	do do do			S	S	VS	VS	S	VS	VS
A13B	do do do			S	S	VS	S	S	S	S
A15B	do do do			R	S	S	VS	S	VS	S
A17B	do do do			R	R	VS	R	R	S	R
A19B	do do do			S	S	VS	S	VS	VS	VS
A21A	do do do			S	S	VS	S	S	VS	S
A24A	do do do			S	S	VS	S	S	S	VS
A25A	do do do			S	S	VS	VS	S	VS	S
A26A	do do do			S	VS	VS	S	VS	VS	VS
B2A	Elberta, Utah, 1963			S	S	VS	S	VS	VS	VS
B2B	do do do			S	S	VS	VS	S	VS	VS
B4A	Jerome, Idaho, do			R	S	VS	VS	S	VS	VS
B4B	do do do			S	S	VS	VS	S	VS	VS
B4D	do do do			R	S	--	S	S	VS	VS
B5A	Riverton, Utah do			R	S	VS	S	S	S	S
B5B	do do do			S	S	VS	VS	S	VS	VS
B5C	do do do			R	S	S	S	S	S	S
B6A	N. Logan, Utah do			R	S	VS	S	S	S	O
B6D	do do do			S	S	VS	S	S	S	O
B7B	Corinne, Utah do			S	S	VS	S	S	VS	VS
B7C	do do do			S	S	VS	S	S	VS	VS
B8A	Thatcher, Utah do			S	S	VS	S	S	VS	VS
B8D	do do do			S	S	VS	VS	S	VS	VS
B9A	Riverton, Utah do			S	S	VS	VS	VS	VS	VS
B9B	do do do			S	S	VS	S	S	VS	VS
B10C	Elberta, Utah do			R	R	S	S	S	VS	VS
B11C	N. Logan, Utah do			S	S	S	S	S	VS	R
B13A	do do do			S	S	VS	VS	S	VS	VS

^{a/} Results based on at least 20 plants of each species inoculated except tobacco with 5 plants inoculated

^{b/} 0 = no infection; VR = very resistant (CT grades 0.1-2.3), R = resistant (2.4-4.5), S = susceptible (4.6-6.7) VS = very susceptible (6.8-9.0).

Greenhouse Tests of Curly Top Resistance

By: C. L. Schneider

Materials and Methods

Two groups of sugarbeet lines were tested in the greenhouse for resistance to curly top virus. The first group was tested in a series of experiments from late 1963 to early 1964 and comprised 53 lines from the USDA Crops Research Laboratory, Logan, Utah. Twenty-five of these lines had been tested for curly top resistance in the field prior to 1964. The second group was tested in a series of 16 experiments in the summer and autumn of 1964, and comprised 103 lines from the Logan, Utah, Laboratory and 7 from Fort Collins, Colorado. All of the lines of the second group were included in field tests of curly top resistance at Thatcher, Utah, in 1964, conducted by Albert M. Murphy.

Inoculation tests were conducted in the greenhouse in accordance with methods outlined by Giddings^{1/} and Bennett^{2/}. Temperatures were maintained at minimum of about 23°C. Seedlings in the cotyledon stage were transplanted, 4 per pot, to 6" pots of soil previously sterilized with methyl bromide. To promote vigorous plant growth, 100 ml of Hoagland solution were added per pot after transplanting.

Beet leafhoppers from a nonviruliferous stock culture were caged on sugarbeets with curly top for about 7 days to acquire the curly top virus. Isolates similar in virulence to CTV strain 11 were employed. Inoculation of seedlings was accomplished by attaching one small glass cage, containing one viruliferous leafhopper, to a cotyledon of each seedling under test. Cages were removed 7 days later.

In each experiment there were 5 replicates in randomized blocks, making a total of 20 plants inoculated. Usually 9 lines to be evaluated and a check variety included for purpose of comparison comprised an experiment. Variety US 75 was the check variety in the tests of Group I and US 41 in the tests of Group II.

Curly top symptoms generally began to appear within 7 days after inoculation. During the tests, the average pre-symptom period (time in days from exposure to virus to expression of symptoms) and average incidence of infection (no. of plants with symptoms/no. of plants inoculated) were obtained for each line. Six weeks after inoculation, each plant was assigned a disease severity grade ranging from 0 (no symptoms) to 9 (dead), and an average grade was computed for each line. Inasmuch as absolute values of pre-symptom period, incidence of infection and disease severity of the same variety may vary from test to test (table 1), these values were converted to relative terms, expressed in percent of that of the check variety included in each test, in order to facilitate comparison of results of different tests.

^{1/} Giddings, N. J., 1937, A greenhouse method for testing resistance to curly top in sugarbeets, *Phytopathology* 27:773-779.

^{2/} Bennett, C. W., Personal communication.

Table 1 - Reaction of sugarbeet check variety US41 to curly top virus in 16 greenhouse inoculation tests.

Test No.	Curly Top Virus Culture No.	Incidence ^{a/b/} Of Infection (Pct)	Curly Top ^{a/c/} Severity Grade	Pre-Symptom ^{a/d/} Period (Days)
1	A1A	65	5.4	17.9
2	A1A	90	5.3	10.5
3	A1A	30	5.5	23.2
4	A1A	75	5.5	15.6
5	A1A	40	5.0	22.3
6	A13B	90	4.7	15.0
7	A13B	90	6.0	12.6
8	B4B	60	4.6	16.3
9	A9C	75	5.4	17.3
10	A1A	60	4.5	15.7
11	A1A	75	4.8	15.1
12	A26A	50	5.2	13.3
13	A13B	60	4.6	12.5
14	A1A	90	4.8	15.7
15	A1A	64	4.4	16.0
16	A1A	58	4.5	14.9

^{a/} - Results expressed as mean of 5 replicate pots of 4 plants each in each test.

^{b/} - Number of plants with curly top symptoms ÷ Total plants inoculated.

^{c/} - Severity grades range from 0 (no symptoms) to 9 (dead).

^{d/} - Period from date of inoculation until expression of curly top symptoms.

Results

In the first group of tests, each line was tested in 2 separate experiments, thereby affording an opportunity to determine concordance between tests. In table 2, curly top severity ratings obtained in 2 tests are compared. A highly significant correlation was shown between results obtained in 2 separate tests.

All of the 110 sugarbeet lines of Group II were tested in the curly top nursery at Thatcher, Utah, in 1964. Highly significant correlations between field disease severity grades and greenhouse disease severity grades are shown (table 3). Similarly, among the 25 lines of Group I tested in the field, a highly significant correlation coefficient of .531** was obtained between field and greenhouse determinations. A highly significant negative correlation is shown between field determinations and pre-symptom period in the greenhouse (table 4). There was no correlation between field determinations and incidence of infection in the greenhouse (table 5).

Conclusions

Wide differences in resistance of sugarbeet lines to curly top virus were consistently demonstrated in controlled exposures to curly top virus isolates in the greenhouse. Disease severity ratings in the greenhouse, and to a lesser degree, greenhouse pre-symptom period of the lines, give a fair approximation of their relative degree of resistance to curly top in the field. Incidence of infection in the greenhouse, on the other hand, was not indicative of field reaction.

Figure 1, page 105, illustrates severity ratings of curly top symptoms in the greenhouse.

Table 2 - Distribution of 53 sugarbeet lines according to curly top severity rating in 2 greenhouse inoculation tests: Number of lines in each severity rating class

Curly Top Severity Rating ^{a/} 1st Test (y)	Curly Top Severity Rating Classes ^{a/} , 2nd Test (x)							Total
	71-80	81-90	91-100	101-110	111-120	121-130	131-140	
61-70	1	-	1	1	-	-	-	3
71-80	2	4	6	-	-	-	-	12
81-90	3	7	9	1	-	-	-	20
91-100	-	4	3	3	1	-	-	11
101-110	-	-	1	-	-	-	-	1
111-120	-	-	1	-	-	-	1	2
121-130	-	-	-	-	1	-	1	2
131-140	-	-	-	-	2	-	-	2
TOTAL	6	15	21	5	4	0	2	53

Correlation between tests

$$r_{xy} = .598^{**}$$

a/ Classes represent curly top severity grades expressed in percent of that of check variety US75 included in each test.

Table 3 - Distribution of 110 sugarbeet lines according to curly top grades in field and greenhouse tests: number of lines in each class.

Curly Top Severity Classes Field Test (y)	Curly Top Severity Classes ^{a/} , Greenhouse Tests (x)					Total
	50-69	70-89	90-109	110-129	130-149	
6.0-6.9	-	-	-	-	2	2
5.0-5.9	1	1	7	6	3	18
4.0-4.9	3	9	18	4	2	36
3.0-3.9	2	9	11	5	-	27
2.0-2.9	2	11	6	3	-	22
1.0-1.9	3	-	2	-	-	5
TOTAL	11	30	44	18	7	110

Correlation between field and greenhouse determinations: $r_{xy} = .421^{**}$

^{a/} Classes represent curly top severity grades expressed in percent of that of check variety US41, included in each test. Grades range from 0 = healthy to 9 = dead.

Table 4 - Distribution of 110 sugarbeet lines according to curly top severity grades in field test and pre-symptom period in greenhouse tests: Number of lines in each class.

Curly Top Severity Classes In Field Test (y)	Curly Top Pre-Symptom Period Classes ^{a/} In Greenhouse Tests (X)							Total
	60-79	80-99	100-119	120-139	140-159	160-179	180-199	
6.0-6.9	2	-	-	0	-	-	-	2
5.0-5.9	3	9	4	2	-	-	-	18
4.0-4.9	3	9	15	5	1	3	-	36
3.0-3.9	1	9	12	4	0	0	1	27
2.0-2.9	-	8	3	5	4	2	-	22
1.0-1.9	-	1	1	1	2	-	-	5
TOTAL	9	36	35	17	7	5	1	110

Correlation of field grades and greenhouse pre-symptom period: $r_{xy} = .334^{**}$

^{a/} Classes represent pre-symptom period in days expressed in percent of that of check variety US41 included in each test.

Table 5 - Distribution of 110 sugarbeet lines according to curly top severity in field test and incidence of curly top in greenhouse tests: Number of lines in each class.

Curly Top Severity Classes In Field Test (y)	Curly Top Incidence Classes ^{a/} In Greenhouse Tests (x)							Total
	20-39	40-59	60-79	80-99	100-119	120-139	140-159	
6.0-6.9	-	-	-	-	1	1	-	2
5.0-5.9	1	3	7	5	1	1	-	18
4.0-4.9	1	6	5	13	6	4	1	36
3.0-3.9	1	5	2	6	10	3	-	27
2.0-2.9	-	3	5	6	7	1	-	22
1.0-1.9	-	1	1	2	0	-	1	5
TOTAL	3	18	20	32	25	10	2	110

Correlation of field grades and incidence of curly top in greenhouse:
 $r_{xy} = .070$ (N.S.)

^{a/} Classes represent incidence of curly top among inoculated plants expressed in percent of that of check variety US41 included in each test.



Figure 1.--Reaction of 3 sugarbeet lines
to curly top virus in the greenhouse:
A - SL 742; B - US 75; C - Line 1128.

Curly Top Screening Test, Thatcher, Utah

By Albert M. Murphy

Introduction

In 1964 the curly top screening work was changed to a new location. The field was located about 3 miles southwest of the 1963 location and consisted of 6 acres more or less. The new location had several advantages: (1) better soil, (2) the field was closer to the natural (desert) breeding area of the beet leafhopper, and (3) most importantly, a more adequate supply of irrigation water without restriction on the time the water could be used. This made it possible to irrigate during daylight, or regular hours of duty, and thus put an end to irrigation inconveniences suffered in 1962 and 1963.

Material for selection and testing was received from all ARS sugar-beet breeders in varying amounts. In addition, material for testing was also received from all beet sugar companies, except one (American Crystal), concerned with the curly top problem.

Methods

Buffer areas of a curly top susceptible European variety were planted on each end of the field as well as in strips 15 feet wide, crosswise of the field at 100-foot intervals. This variety served both as a good host for the beet leafhopper and multiplication of the curly top virus. It was planted May 18 and 19, which was the earliest it could be planted under existing weather conditions in the spring of 1964. Sugarbeet roots infected with the curly top virus, which were harvested in the fall of 1963, were transplanted May 20 and 21 in every other row within the 15-foot strip and also in the buffer planting at each end of the field. These roots served as a source of inoculum readily available for all known strains of the curly top virus existing in Utah and Idaho. The material to be tested was planted June 25-29. The test plots varied in size from single rows 25 feet long to four-row plots 50 feet long, while material grown for the purpose of making selections was planted in plots that varied from 2 rows 50 feet long to 16 rows 150 feet long.

Results and Conclusions

The curly top epidemic was the slowest getting under way of any in the writer's experience in creating curly top exposures, as the first curly top symptoms were not observed in the susceptible European variety until June 30. There were two reasons for this: (1) the population of leafhoppers that moved into the field was extremely low and (2) the wet, cold, late spring retarded their reproduction rate and activity in the field and, thus, delayed the spread of curly top.

The very unfavorable spring weather was followed by hot summer weather, and the disease developed at a rapid rate. The final exposure was judged to be of moderate intensity. Because of unfavorable conditions early in the season, the exposure over the entire field was not quite as even as desired as judged by the percent of curly top in the same variety in a different location; but the over-all test was considered the most satisfactory since moving the screening tests to Utah three years ago.

Curly top information obtained for all sugarbeet breeders not stationed at Logan was sent to them. In addition to obtaining curly top information on varieties, selections were made for curly top resistance for all ARS breeders. The number of roots selected varied widely. In some cases the selected roots were shipped to the breeders concerned, while in other cases they were put in storage at Logan and seed will be produced from them in 1965.

236 lines from Logan were screened for the curly top resistance in the field. These same lines were or are now being screened by C. L. Schneider in the greenhouse. Thirty-four of the lines were hybrids and the curly top information on these numbers appears elsewhere in this Part.

In Table 1 is recorded the results obtained in the field from 202 lines compared with the same lines in the greenhouse; however, tests have only been completed for 110 lines in the greenhouse.

It has been found, based on 110 lines so far tested in both the field and greenhouse, that the average grade of severity is slightly over 1 full point (4.6 for greenhouse to 3.5 for field) higher in the greenhouse test than in the field.

In a few cases--for example, entry numbers 3, 69, 85, and 86--the lines performed much better in the field than in the greenhouse, which indicates that if the lines are discarded on the basis of the greenhouse tests alone, valuable breeding material would be lost. Further experimentation will be required to establish the reliability of the greenhouse test for evaluation of curly top resistance.

Table 1 - Results obtained in field and greenhouse curly top screening tests from a group of Logan experimental inbreds¹⁷

Entry No.	Current No.	No. Beets in 50'	% C.T. 8/7	% C.T. 8/21	C. T. Grade	
					Field	Greenhouse
US 33 Check			37.1	70.4	5	
1	3504-8	31	12.9	45.2	5	3.3
2	3506-2	19	10.5	31.6	4	4.6
3	3514-1	37	0	2.7	1	3.4
4	3514-3	6	0	16.7	3.5	4.4
5	3507-3	28	3.6	25.0	3.5	3.2
6	3537-7	27	3.7	22.2	4	4.3
7	3509-1	29	20.7	24.1	4	4.0
8	3509-5	14	7.1	42.9	4.5	4.9
9	3509-6	36	2.8	25.0	4	5.3
10	3509-10	36	25.0	41.7	4	3.8
11	3511-1	35	11.4	34.3	4	4.6
12	3511-8	33	15.2	39.4	4.5	4.5
13 ^{2/}	3511-10	19	5.3	15.8	4	3.1
14	3511-2	42	7.1	19.0	4.5	3.1
15 ^{2/}	3512-1	29	3.4	24.1	5.5	5.4
16 ^{2/}	3515-2	9	11.1	44.4	5	4.7
US 33 Check			44.3	84.8	6	
17	3515-3	42	11.9	33.3	4.5	4.0
18	3515-1	33	9.1	36.3	4	4.0
19	3517-3	40	5.0	7.5	5	6.3
20	3517-6	23	4.3	21.7	5	6.0
21	3517-7	39	2.6	10.3	4.5	6.5
22	3518-1	35	11.4	40.0	4	4.1
23	3518-5	30	13.3	33.3	4	4.5
24	3518-6	28	14.3	42.9	3.5	3.3
25	3518-7	48	10.4	33.3	3	4.5
26	3519-1	29	6.9	13.8	2	4.4
27	3519-2	31	9.7	12.9	2.5	3.4
28	36139-21	21	0	19.0	2.5	2.7
29	36139-53	25	4.0	4.0	1.5	2.6
30	3500-3	28	0	7.1	2.5	
31	3549-6	10	10.0	40.0	4	
32	3550-1	22	4.5	18.2	2.5	4.0
US 33 Check			51.7	75.9	6.5	
33	3551-2	25	12.0	12.0	1.5	
34	3552-3	29	0	10.3	2	
35	3553-1	24	0	4.2	2	
36	3555-4	28	0	3.6	3	4.3
37	3555-4	33	0	6.1	2.5	4.0
38	3558-3	29	0	6.9	2.5	3.9
39	3573-4	34	2.9	23.5	4.5	5.8
40	3573-7	32	6.3	37.5	5	6.4
41	3573-8	37	5.4	29.7	5	7.5
42	3574-1	36	22.2	44.4	5	5.5

Table 1 (cont.)

Entry No.	Current No.	No. Beets in 50'	% C.T. 8/7	% C.T. 8/21	C. T. Grade	
					Field	Green- house
43	3574-2	27	18.5	51.9	6	7.3
44	3574-5	33	12.1	63.6	5.5	7.0
45	3574-6	31	32.3	87.1	5	6.0
46	3574-7	26	15.4	34.6	3	4.8
47	3575-1	29	0	10.3	3	5.0
48	3575-2	16	0	12.5	3.5	4.6
US 33 Check			19.3	45.6	5	
49	3575-3	34	0	5.9	3.5	4.6
50	3575-5	22	0	13.6	3.5	4.0
51	3575-6	28	0	3.6	3	4.1
52	3576-1	29	0	6.9	3	3.8
53	3576-2	31	6.5	22.6	4	3.9
54	3576-3	32	6.3	6.3	4	4.7
55	3576-6	36	11.1	33.3	4.5	5.4
56	3576-7	17	5.9	23.5	4.5	
57	3576-9	30	3.3	16.7	5	4.4
58	3577-2	33	15.2	36.4	4.5	5.2
59	3577-3	35	14.2	54.3	5	4.8
60	3704-10	27	0	18.5	3.5	4.1
61	3704-11	32	3.1	9.4	2	4.4
62	3704-1	33	0	6.1	3	3.9
63	3710	38	5.3	10.5	2.5	4.2
64	3567-1	24	4.2	8.3	3.5	5.0
US 33 Check			39.7	72.4	6	
65	3568-2	28	17.9	39.3	5.5	5.1
66	3569-1	18	0	22.2	3	5.5
67	3570-4	35	0	2.9	2	4.7
68	3571-2	37	0	13.5	2	5.8
69	3572-1	41	0	0	2	5.8
70	3526-1	26	0	7.7	2.5	4.1
71	3526-6	21	0	14.3	3	3.9
72	3526-9	23	4.3	8.7	3	4.6
73	3526-4	44	15.9	54.5	4.5	4.8
US 41 Check			10.0	30.0	4	
US 33 Check			25.4	58.7	5	
74	3526-8	12	0	8.3	2.5	4.0
75	3527-1	44	0	9.1	2.5	3.8
76	3528-1	28	3.6	21.4	3.5	4.3
77	3528-2	38	5.3	23.7	4	4.4
78	3528-3	36	0	8.3	3.5	5.0
79	3501-2	35	2.9	14.3	2.5	4.9
80	3502-3	33	3.0	24.2	3.5	4.7
81	3705-2	30	0	6.7	2.5	3.8
82	3705-3	50	0	2.0	2	4.2
83	3705-6	39	2.6	5.1	2	5.3
84	3706-4	30	0	0	1.5	3.3
85	3706-5	31	0	3.2	1	4.5

Table 1 (cont.)

Entry No.	Current No.	No. Beets in 50'	% C.T. 8/7	% C.T. 8/21	C. T. Grade	
					Field	Green- house
86	3706-6	37	0	2.7	1.5	4.6
87	3705-4	16	0	18.8	2.5	4.8
88	3706-3	36	0	5.6	2	4.4
89	3608-2	21	9.5	38.1	4	5.1
US 33 Check			19.7	57.7	5.5	
90	3561-4	30	3.3	10.0	4	4.6
91	3562-2	34	2.9	29.4	4	3.9
92	3563-3	24	12.5	41.7	4	3.4
93	3564-6	38	0	10.5	2	4.0
94	3565-7	23	4.3	21.7	3.5	3.6
95	3513-8	34	0	11.8	3.5	4.9
96	3513-10	41	0	14.6	3.5	5.1
97	3601-1	40	0	17.5	3.5	4.8
98	3566-3	37	0	8.1	5	4.9
99	3566-4	44	6.8	27.3	4.5	4.1
100	3643-1	27	3.7	14.8	3.5	5.7
101	3643-5	35	11.4	31.4	4.5	5.0
102	3643-8	37	5.4	48.6	4.5	6.2
103	3643-11	27	11.1	37.0	4.5	5.7
104	3643-13	38	2.6	23.7	4	4.8
105	3643-7	43	14.0	23.3	3.5	5.4
US 33 Check			6.3	32.5	4.5	
106	3644-1	38	5.3	15.8	4	4.9
107	3644-3	46	2.2	23.9	4	5.5
108	3644-5	51	3.9	17.6	4	6.1
109	3644-7	47	2.1	10.6	3	
110	3644-8	42	2.4	7.1	3.5	
111	3644-9	43	7.0	23.3	3.5	
112	3505-4	40	2.5	22.5	4	
113	3505-5	31	0	19.4	4	
114	3602-14	33	0	12.1	3	
115	3604-5	30	0	6.7	4	
116	3607-6	38	2.6	7.9	3.5	
117	3613-11	14	0	21.4	2.5	
118	3535-1	38	10.5	31.6	3	
119	3535-2	36	0	13.9	3.5	
120	3535-3	36	8.3	30.6	4.5	
121	3535-10	39	5.1	20.5	4	
US 33 Check			14.8	37.0	5	
122	3535-9	32	15.6	21.9	4.5	
123	3535-7	26	7.7	26.9	4	
124	3536-1	30	3.3	16.7	3	
125	3536-3	27	7.4	25.9	3	
126	3536-7	31	3.2	9.7	3.5	
127	3536-6	35	2.9	2.9	2.5	
128	3536-4	40	5.0	20.0	3.5	
129	3536-5	24	8.3	33.3	4	

Table 1 (cont.)

Entry No.	Current No.	No. Beets in 50'	% C.T. 8/7	% C.T. 8/21	C. T. Grade	
					Field	Green- house
130	3578-9	36	0	2.8	2	
131	3578-14	39	0	12.8	2.5	
132	3520-2	32	3.1	3.1	1.5	
133	3520-6	39	0	7.7	2.5	
US 33 Check			15.4	52.3	5	
US 33 Check			46.2	67.9	5	
134	3541-6	26	3.8	11.5	2.5	
135	3542-4	21	9.5	19.0	3.5	
136	3543-2	25	4.0	4.0	2	
137	3544-5	30	0	6.7	2	
138	3545-3	34	0	5.9	3	
139	3546-3	27	3.7	11.1	1.5	
140	3547-4	32	3.1	9.4	3	
141	3548-2	33	3.0	15.2	3.5	
142	3548-5	37	0	10.8	3	
143	3581-3	30	0	6.7	3	
144	3582-16	22	9.1	22.7	2.5	
145	3583-7	17	5.9	11.8	2.5	
146 ^{2/}	3615-8	17	17.6	35.3	4	
147	3616-1	29	3.4	17.2	3	
148 ^{2/}	3620-3	27	14.8	18.5	3	
149 ^{2/}	3621-3	13	15.4	15.4	3	
US 33 Check			51.6	73.4	6	
150	3622-5	18	11.1	27.8	3.5	
151	3623-9	29	3.4	31.0	3	
152	3625-12	44	13.6	20.5	3.5	
153	3626-13	27	11.1	25.9	3	
154	3627-4	27	3.7	22.2	3	
155	3628-1	37	5.4	18.9	3	
156	3629-3	39	0	15.4	2.5	
157	3630-2	28	3.6	25.0	3	
158	3631-10	29	13.8	17.2	3.5	
159	3632-7	32	6.3	28.1	3.5	
160	3633-3	40	2.5	17.5	3	
161	3641-1	26	3.8	23.1	3	
162	3642-8	27	0	22.2	2.5	
163	3634-6	28	7.1	32.1	3	
164	3636-5	31	9.7	19.4	3	
165	3635-8	41	4.9	19.5	3	
US 33 Check			33.3	33.3	5	
166	3638-15	38	5.3	10.5	2.5	
167	3637-1	34	2.9	11.8	3.5	
168	3639-3	29	6.9	17.2	3.5	
169	3640-1	27	7.4	14.8	3.5	
170	36138-7	17	5.9	52.9	7	
171	3700-4	52	0	3.8	3	
172	3700-1	49	0	0	3.5	

Table 1 (cont.)

Entry No.	Current No.	No. Beets in 50'	% C.T. 8/7	% C.T. 8/21	C. T. Grade	
					Field	Greenhouse
173	3700-5	10	0	20.0	3.5	
174	3701-2	32	0	3.1	3.5	
175	3701-3	38	5.3	10.5	3	
176	3708	37	5.4	10.8	3	
177	3700-3	17	5.9	17.6	3	
178	3700-6	35	5.7	11.4	4	
179	3703-2	26	3.8	19.2	3.5	
180	3521-2	37	8.1	18.9	3.5	
181	3521-3	33	12.1	15.2	3.5	
US 33 Check			31.3	59.4	5.5	
182	3521-4	30	6.7	13.3	3.5	
183	3521-5	38	13.2	23.7	4.5	
184	3522-14	35	5.7	40.0	3.5	
185	3522-12	36	13.9	13.9	2.5	
186	3522-2	43	11.6	27.9	2.5	
187	3522-5	33	15.2	33.3	3.5	
188	3522-6	34	2.9	11.8	2.5	
189	3522-7	32	12.5	15.6	3.5	
190	3522-8	35	2.9	8.6	2	
191	3522-9	30	6.6	13.3	2	
192	3522-10	36	2.7	33.3	3	
193	3523-1	38	7.9	18.4	3.5	
194	3523-5	36	16.7	30.6	4.5	
195	3523-6	33	9.1	18.2	3.5	
196	3523-8	26	3.8	7.7	3	
197	3523-10	35	8.6	22.9	4	
US 33 Check			37.5	53.6	5.5	
198	3523-11	31	19.4	35.5	4	
199	3523-12	47	4.3	29.8	4	
200	3523-13	41	7.3	36.6	3.5	
201	3523-14	39	5.1	10.3	2.5	
202	3524-3	35	5.7	40.0	4.5	
US 41 Check			6.0	18.0	3	
US 33 Check			48.1	65.4	5.5	

1/ Field test planted June 29, one row plots, 25 feet long, two replications. Greenhouse test consisted of 4 plants per 6" pot with five replications. Curly top grade 0-9. 0 = healthy, 9 = death due to curly top. Greenhouse tests conducted by C. L. Schneider.

2/ Single row 25' long.

P A R T IV

EVALUATION OF BASIC BREEDING MATERIAL
AND VARIETIES OF SUGARBEETS
SUITABLE FOR THE GREAT LAKES REGION

Foundation Project 26

G. E. Coe

D. L. Mumford

G. J. Hogaboam

Cooperation:

Farmers & Manufacturers Beet Sugar Association
Buckeye Sugars, Inc.
Canada and Dominion Sugar Company, Ltd.
Michigan Sugar Company
Monitor Sugar Division
Northern Ohio Sugar Company
Michigan Agricultural Experiment Station
Wisconsin Agricultural Experiment Station
Western Ontario Agricultural School, Ridgetown, Ontario

EVALUATION OF SUGARBEET VARIETIES AND BASIC BREEDING MATERIAL SUITABLE FOR THE GREAT LAKES REGION

The evaluation program was continued in 1964 on a cooperative basis, as it has been for several years. The report is divided into two sections: 1) Regional field tests of advanced hybrids and varieties that are candidates for grower use; 2) miscellaneous hybrids evaluated for combining ability of their male and female parents.

Section 1. Regional Field Tests of Hybrids and Varieties

The objective of the cooperative regional field tests was to evaluate new hybrids and open-pollinated monogerm varieties in comparison with the present hybrid commercial and an open-pollinated multigerm with high leaf spot resistance.

The regional tests for the evaluation of eight varieties were conducted jointly with the Farmers and Manufacturers Beet Sugar Association and its member companies: Canada and Dominion Sugar Co. (p.), Monitor Sugar Division (p.), Michigan Sugar Co. (p.), and Buckeye Sugar, Inc. (p.). In addition, tests were conducted by Western Ontario Agricultural School, Ridgeway, Ontario (p.), and Hancock Experimental Farm, College of Agriculture, University of Wisconsin (p.). Eight varieties were included in field trials conducted by Northern Ohio Sugar Co. (p.).

RESULTS

Tons of Roots per Acre

The hybrid (SP6121xEL61G1)msxSP5822-0 gave consistently the best performance. Its performance in the test at Van Wert, Ohio, was the only location where it was seriously out of first place in yield of roots per acre.

Pounds of Recoverable Sugar per Ton

SP5822-0 was consistently above average in pounds of recoverable sugar per ton of roots and gave the best overall performance in this respect. The hybrid SL(129x133)msxSP5822-0 was very nearly equal to SP5822-0 in quality. The present commercial hybrid SL126msxSP5460-0 and hybrid SL(126x128)msxSP5822-0 were not significantly below SP5822-0 in quality in either Michigan or Ohio tests.

Pounds of Recoverable Sugar per Acre

The hybrid (SP6121xEL61G1)msxSP5822-0 exceeded all others in all tests except at Van Wert, Ohio. In the combined values for Michigan tests it was significantly above the next high contender. Second high in production, when the entire area is considered, was the hybrid SL(129x133)msxSP5822-0, followed closely by the commercial SL126msxSP5460-0; and although these hybrids were significantly below (SP6121xEL61G1)msxSP5822-0 in root yield, their quality was higher and gave them a production of recoverable sugar per acre not significantly different from the best (all trials considered).

Leaf Spot Readings

In leaf spot resistance the hybrid (SP6121xEL61G1)msxSP5822-0 was as highly resistant as SP5822-0. The broad base monogerm varieties SP63194-0 and SP63197-0 carried the next highest level of resistance followed by (SL129xSP6121)msxSP5822-0 with the least resistance in the hybrids that had no resistance bred into the female parent. Although leaf spot occurred relatively early in the season, cool weather in August seemed to delay further development of the disease. Possibly this explains why there was no apparent correlation between the leaf spot resistance and the quality results in the tests.

Black root was not a limiting factor in any of the tests this year, with the possible exception of the trial at Van Wert, Ohio. Black root was noted in this trial, but it is doubtful that it played more than a minor role in limiting yield.

VARIABILITY - In studying the combined analyses it is of interest to note the size of the variability (variance or M.S.) ascribed to locations within a state in comparison with the variability ascribed to varieties. Even with allowances made for weather, soil type, etc., it would seem that management of the sugarbeet crop from pre-planting to harvest can make more difference to the farmers in net return than can varieties. As an example, in Michigan, for quality the variability for locations was over 27 times as great as the variability for varieties.

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Standard Footnotes for all Experiments with F. & M. as a Cooperator:

- a) Calculated according to Great Western formula rearranged as follows:

$$RC = TA \times 2000 \times \%S - FL \times P_K$$

RC is the calculated recoverable sugar.

TA is the yield of roots in tons per acre.

S is sucrose

FL is factory loss (we used 0.30%)

P_K is $1 - (MP \times 100 - CJP / 100 - MP \times CJP)$. This factor is constant for any given CJP (clear juice purity) if the MP (molasses purity) is held constant. We used 62.5% MP for all calculations.

- b) Clear Juice Apparent Purity determinations were made following procedures worked out by M. G. Frakes of Michigan Sugar Co. These values approximate the thin juice purities obtained in the factory.
- c) Rating scale: 0= no evidence of disease; 10= complete necrosis due to leaf spot.

OBSERVATIONAL TEST - 1964

Plant Industry Station
Beltsville, Maryland

by G. E. Coe

Single-plot (4-row) Test, Conducted Primarily for Leaf Spot Evaluation

Variety	: Root yield : : per acre :	: Sucrose : : percent :	: Raw juice : : apparent : : purity :	: Leaf spot : : rating <u>1</u> /
	<u>tons</u>	<u>percent</u>	<u>percent</u>	
SL (126 X 128) X SP 5822-0	19.2	12.8	78.35	4
SL (129 X 133) X SP 5822-0	20.1	12.7	78.40	4
SP 63194-0	22.4	13.4	79.82	3
SP 63197-0	23.0	13.5	81.38	3
SL 126 X 5460-0	20.8	12.0	75.31	4
SP 5822-0	22.5	12.5	76.68	2
SP 6322-0	24.3	13.3	78.64	2
US 401	21.8	12.0	76.58	4
SP 6121-01 MS	-	-	-	3
EL 61G1	-	-	-	3
SL (126 X 128)	-	-	-	5
SL (129 X 133)	-	-	-	5
SL 126	-	-	-	5

1/ 0 = no Leaf spot; 10 = complete destruction of foliage.

Cooperator: F & M Beet Sugar Association Year 1964
 Location: Sebewaing, Bay City, Kawkawlin, & Marlette, Mich.
Van Wert and Leipsic, Ohio Exp. Combined

Variety	Quality ^d			x Quantity			= Product ^e		
	: Sugar :			: Root :			: Sugar :		
	: Recoverable :			: Yields :			: Yields :		
	: Pounds per ton:			: Tons per Acre :			: Pounds per Acre:		
	Mich. Ohio All			Mich. Ohio All			Mich. Ohio All		
SL(126x128)msxSP5822-0	273	310	285 ⁴	22.0	17.1	20.4 ⁵	5991	5297	5759 ⁴
SL(129x133)msxSP5822-0	278	313	289 ²	22.4	17.0	20.6 ⁵	6190	5289	5890 ³
(SL129xSP6121)msxSP5822-0	269	294	277 ⁷	23.0	16.1	21.0 ²	6165	4746	5692 ⁶
(SP6121xEL61G1)msxSP5822-0	272	297	280 ⁶	23.9	17.2	21.7 ¹	6553	5119	6075 ¹
SP63194-0	266	287	273 ⁸	21.7	15.8	19.7 ⁸	5726	4527	5326 ⁸
SP63197-0	269	298	279 ⁶	21.8	15.9	19.8 ⁸	5841	4743	5475 ⁷
SL126msxSP5460-0	275	307	286 ⁴	22.4	16.9	20.4 ⁵	6128	5207	5821 ³
SP5822-0	278	319	291 ²	21.4	16.6	19.8 ⁸	5926	5281	5711 ⁶
General Mean	272	303	282	22.3	16.5	20.4	6065	5026	5719
S. E. Var. Mean	2.5	4.7	2.5	0.36	0.87	0.35	102	295	119
Above as % Gen. Mean	.94	1.6	.88	1.61	5.27	1.71	1.68	5.90	2.08
LSD 5% Point	8	16	7	1.1	N.S.	1.0	301	N.S.	342

ANALYSIS OF VARIANCE DATA									
SOURCE	: Quality			: Quantity			: Product		
	:D/F:Vari-	: F.	: Vari-	: F.	: Vari-	: F.	: Vari-	: F.	
	: :ance	: Ratio	: :ance	: Ratio	: :ance	: Ratio	: :ance	: Ratio	
LOCATIONS									
Four in Mich.	: 3	: 2062	: 82.48**	: 55.37	: 109.00**	: 1296346	: 31.20**		
Two in Ohio	: 1	: 0	: N.S.	: 37.21	: 24.64**	: 3252613	: 18.71**		
Between Mich.& Ohio	: 1	: 10107	: 168.45**	: 355.74	: 462.00**	: 11518354	: 94.88**		
All Six (Total)	: 5	: 3258	: 90.50**	: 112.06	: 152.88**	: 3732001	: 43.79**		
VARIETIES									
Considered in Mich.	: 7	: 74	: 2.96*	: 2.62	: 5.15**	: 261883	: 6.30**		
" " Ohio	: 7	: 227	: 5.04*	: 0.62	: N.S.	: 187545	: N.S.		
" All Locations	: 7	: 241	: 6.69**	: 2.46	: 3.36*	: 328027	: 3.85**		
INTERACTION (Loc. x Var.)									
Four in Mich.	: 20 ^f	: 26	: 0.51		: 41547				
Two in Ohio	: 7	: 45	: 1.51		: 173865				
Between Mich.& Ohio	: 7 ^f	: 60	: 0.77		: 121402				
All Six (Total)	: 34 ^f	: 37	: 0.73		: 85230				

- d. Calculated as follows: % sucrose minus factory loss (0.3%) times P_K factor for the clear juice purity times twenty.
- e. The averages reported here are calculated from plot averages and differ somewhat (less than 1%) from the multiplication of pounds sugar per ton by tons per acre.
- f. Loss of 1 D/F due to calculation of missing plot data for entry 4, (SP6121xEL61G1)msxSP5822-0, for experiment 4 at Kawkawlin, Michigan.

Cooperator: F & M Beet Sugar Association Year 1964
 Location: Sebewaing, Bay City, Kawkawlin, & Marlette, Mich.
Van Wert and Leipsic, Ohio Exp. Combined

Variety	Percent Sucrose			Percent Purity			Leaf Spot g.&c.
	Mich.	Ohio	All	Mich.	Ohio	All	All
SL(126x128)msxSP5822-0	15.93	17.84	16.57	92.89	93.47	93.09	3.4
SL(129x133)msxSP5822-0	16.20	18.04	16.81	92.85	93.35	93.02	3.2
(SL129xSP6121)msxSP5822-0	15.81	17.38	16.33	92.63	92.33	92.53	2.8
(SP6121xEL61G1)msxSP5822-0	16.16	17.64	16.65	92.49	92.12	92.37	1.7
SP63194-0	15.79	17.27	16.28	92.05	91.59	91.89	2.2
SP63197-0	15.95	17.69	16.53	92.22	92.16	92.20	2.0
SL126msxSP5460-0	16.21	17.90	16.77	92.44	92.88	92.59	3.6
SP5822-0	16.18	18.20	16.85	92.93	93.80	93.22	1.7
General Mean	16.03	17.74	16.60	92.55	92.71	92.61	2.6
S. E. Var. Mean	.0887	.1963	.0867	.1790	.2580	.1700	.12
Above as % Gen. Mean	0.6	1.1	0.5	0.2	0.3	0.2	4.6
LSD 5% Point	0.26	N.S.	0.25	0.53	0.86	0.49	0.3

ANALYSIS OF VARIANCE DATA

SOURCE	Percent Sucrose		Percent Purity		Leaf Spot	
	D/F	Var-	F.	Var-	F.	D/F
		ance	Ratio	ance	Ratio	g.:ance
LOCATIONS						
Four in Mich.	3	3.91	198:124.44***	10.06	97:78.61**	:
Two in Ohio	1	.61	63: 7.99*	3.98	00:29.90**	:
Between Mich.& Ohio	1	31.25	88:602.29***	.23	01: N.S.	:
All Six (Total)	5	8.72	69:193.50***	6.88	39:39.68***	4:0.735:10.65**
VARIETIES						
Considered in Mich.	7	0.12	87: 4.09***	0.42	46: 3.31*	:
" " Ohio	7	0.19	76: N.S.	1.22	50: 9.20***	:
" All Locations	7	0.27	44: 6.08***	1.30	62: 7.53***	7:3.016:43.71**
INTERACTION						
Four in Mich.	20 ^f	0.03	15: :	0.12	81: :	:
Two in Ohio	7	0.07	71: :	0.13	31: :	:
Between Mich.& Ohio	7	0.05	19: :	0.34	34: :	:
All Six (Total)	34 ^f	0.04	51: :	0.17	35: :	27 ^f :0.069:

f. See other summary page

g. Combined data from locations where leaf spot could be read. The locations with their average rating in parentheses are as follows: in Mich., Sebewaing (2.9), Bay City (2.5), Kawkawlin (2.6); Van Wert, Ohio (2.8), and Ridgetown, Ontario (2.2).

Design #1

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Harold Gremel, Sebewaing, Michigan

Cooperation: F&M Beet Sugar Assn. - Michigan Sugar Company

Date of Planting: May 10, 1964

Date of Harvest: Oct. 23, 1964

Experimental Design: 8 x 8 Latin Square - Design #1

Size of Plots: 4 Rows x 28' Long x 28" between rows

Harvested Area per Plot for Root Yield: 4 Rows x 28' Long

Samples for Sucrose Determination: One 10-beet sample taken just prior to harvest from each plot. 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1961 - Pasture - No fertilizer
1962 - Corn - 250# 6-24-12
1963 - Beans -250# 6-24-12 with
Manganese and zinc

Fertilization of Beet Crop: 400# - 60% Potassium plowed down
in fall 1963
500# 4-40-0 with Manganese and Boron
(at planting time)

Black Root Exposure: None

Leaf Spot Exposure: Moderate

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist seed bed at planting. Below normal moisture thruout growing season.

Reliability of Test: Good

Cooperator: F & M Beet Sugar Association - Mich. Sugar Co. Year 1964

Location: Harold Gremel Farm, Sebawaing, Michigan Exp. 1

8 x 8 Latin Square

Variety	Acre Yield		Sucrose %	Clear Juice App. Purity ^b %	Leaf Spot ^c rating	Beets Per 100' No.
	Sugar Recoverable ^a lbs.	Roots tons				
SL(126x128)msxSP5822-0	5890	21.1	16.39	92.53	4.0	110
SL(129x133)msxSP5822-0	6072	21.4	16.71	92.25	3.8	105
SL(129xSP6121)msxSP5822-0	5433	20.1	16.24	91.56	3.4	96
(SP6121xEL61G1)msxSP5822-0	6398	22.3	16.91	92.21	1.8	86
SP63194-0	5590	19.8	16.71	92.26	2.5	104
SP63197-0	5465	19.4	16.72	91.86	2.0	98
SL126msxSP5460-0	5832	20.6	16.88	91.91	3.9	103
SP5822-0	5481	19.5	16.56	92.40	2.0	103
General Mean	5770	20.5	16.64	92.12	2.9	101
S. E. Var. Mean	272	.62	.263	.559	.14	2.4
Above as % Gen. Mean	4.7	3.0	1.6	0.6	4.8	2.4
LSD. 5% Point	N. S.	1.8	N. S.	N.S.	0.4	7

Latin Square Analysis			Variance Table				
			Mean Squares				
Source of Variation	D/F						Beets
		Recoverable				Leaf	100'
		Sugar	Roots	Sucrose	Purity	Spot	Rows
Between Rows	: 7	: 1,002,119	: 9.1	: 1.03	: 6.35	: .29	: 90
Between Columns	: 7	: 2,201,187	: 10.2	: 1.41	: 3.09	: .14	: 274
Between Varieties	: 7	: 944,586	: 8.4	: .45	: .71	: 7.00	: 425
Remainder (Error)	: 42	: 589.722	: 3.1	: .55	: 2.50	: .17	: 48
Total	: 63	:	:	:	:	:	:
Calculated F. Value	:	: N.S.	: 2.74*	: N.S.	: N.S.	: 41.18**	: 8.90**

Standard Footnotes ^a., ^b., and ^c. on page

Design #5

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Henry Miller, Marlette, Michigan

Cooperation: F&M Beet Sugar Assn. - Michigan Sugar Company

Date of Planting: April 22, 1964

Date of Harvest: Oct. 14, 1964

Experimental Design: 8 x 8 Latin Square - Design #5

Size of Plots: 4 Rows x 28' long x 30" between rows

Harvested Area per Plot for Root Yield: 4 Rows x 29' long

Samples for Sucrose Determination: One 10-beet sample taken just prior to harvest from each plot. 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed

Recent Field History: 1961
1962 - Corn
1963 - Corn

Fertilization of Beet Crop: 400# - 12-12-12 Broadcast
325# - 6-24-12 Planting

Black Root Exposure:

Leaf Spot Exposure: None

Other Diseases and Pests:

Soil and Seasonal Conditions: Wet seedbed - average moisture throughout growing season.

Reliability of Test: Good

Cooperator: F & M Beet Sugar Association-Mich. Sugar Co. Year 1964

Location: Henry Miller Farm, Marlette, Michigan Exp. 5

8 x 8 Latin Square

Variety	Acre Yield		Sucrose %	Clear Juice App. Purity ^b %	Leaf Spot ^c rating	Beets Per 100' No.
	Sugar Recoverable ^a lbs.	Roots Tons				
SL(126x128)msxSP5822-0	5672	21.2	15.46	93.27		94
SL(129x133)msxSP5822-0	5853	21.4	15.65	93.74		93
SL(129xSP6121)msxSP5822-0	5924	22.2	15.34	93.54		92
(SP6121xEL61G1)msxSP5822-0	6291	23.2	15.66	93.49		92
SP63194-0	5386	20.5	15.30	92.72		92
SP63197-0	5207	19.5	15.60	92.70		90
SL126msxSP5460-0	5955	21.8	15.93	93.11		95
SP5822-0	5539	19.8	15.96	93.83		95
General Mean	5728	21.2	15.61	93.30		93
S. E. Var. Mean	207	.58	.221	.341		3.8
Above as % Gen. Mean	3.6	2.7	1.4	0.4		4.1
LSD 5% Point	591	1.7	N.S.	N.S.		N.S.

Latin Square Analysis			Variance Table				
			Mean Squares				
Source of Variation	D/F						Beets
		Recoverable				Leaf	100'
		Sugar	Roots	Sucrose	Purity	Spot	Rows
Between Rows	7	6,425,894	72.09	1.06	3.73		125
Between Columns	7	223,106	2.10	1.37	2.25		30
Between Varieties	7	970,894	12.26	.51	1.60		27
Remainder (Error)	42	342,719	2.71	.39	.93		113
Total	63						
Calculated F. Value		2.83*	4.52**	N.S.	N.S.		N.S.

Standard Footnotes ^a, ^b, and ^c on page

Design #3

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Howard Hayward, Bay City, Michigan

Cooperation: F&M Beet Sugar Assn. - Monitor Sugar Divn.

Date of Planting: April 17, 1964

Date of Harvest: Oct. 15, 1964

Experimental Design: 8 x 8 Latin Square - Design #3

Size of Plots: 4 Rows x 29' long x 28" between rows

Harvested Area per Plot for Root Yield: 4 rows x 29' long

Samples for Sucrose Determination: One 10-beet sample taken just prior to harvest from each plot. 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed

Recent Field History: 1961 - Beans - 350# 12-12-12
1962 - Wheat - 250# 5-20-20 Topdressed
200# 16-8-8
1963 - Potatoes - 500# - 12-12-12 Broadcast
before plowing down a
clover cover crop 1000#
4-11-11 Liquid

Fertilization of Beet Crop: 750# 5-20-20

Black Root Exposure:

Leaf Spot Exposure: Light

Other Diseases and Pests: None

Soil and Seasonal Conditions: Dry seedbed - good growing conditions throughout the growing season.

Reliability of Test: Good

Cooperator: F & M Beet Sugar Association - Monitor Sugar Div. Year 1964

Location: Howard Hayward Farm, Bay City, Michigan Exp. 3

8 x 8 Latin Square

Variety	Acre Yield		Sucrose %	Clear Juice App. Purity ^b %	Leaf Spot ^c rating	Beets Per 100' No.
	Sugar Recoverable ^a lbs.	Roots Tons				
SL(126x128)msxSP5822-0	6234	24.8	15.11	91.59	3.3	86
SL(129x133)msxSP5822-0	6539	25.4	15.51	91.61	2.8	85
SL(129xSP6121)msxSP5822-0	6892	27.4	15.17	91.53	2.6	96
(SP6121xEL61G1)msxSP5822-0	7030	27.8	15.44	90.88	1.9	88
SP63194-0	6267	26.1	15.00	90.07	2.5	91
SP63197-0	6621	26.5	15.14	91.23	2.0	95
SL126msxSP5460-0	6510	26.0	15.36	90.78	3.9	90
SP5822-0	6615	25.8	15.35	91.84	1.1	90
General Mean	6588	26.3	15.26	91.19	2.5	90
S. E. Var. Mean	282	.88	.181	.354	0.18	3.9
Above as % Gen. Mean	4.3	3.3	1.2	.4	7.2	4.3
LSD 5% Point	N.S.	N.S.	N.S.	1.01	0.5	N.S.

Latin Square Analysis				Variance Table			
				Mean Squares			
Source of Variation:	D/F:						Beets
		Recoverable:				Leaf:	100'
		Sugar	Roots	Sucrose	Purity:	Spot:	Rows
Between Rows	7	696,981	6.5	.54	2.65	0	86
Between Columns	7	683,133	8.1	.54	1.12	.29	57
Between Varieties	7	601,292	8.3	.31	2.96	5.86	123
Remainder (Error)	42	636,226	6.1	.26	1.00	.26	120
Total	63						
Calculated F. Value:		N.S.	N.S.	N.S.	2.96**	22.54	N.S.

Standard Footnotes a. b. and c. on page

Design #4

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Fred Ruegseggers, Kawkawlin, Michigan

Cooperation: F&M Beet Sugar Assn. - Monitor Sugar Divn.

Date of Planting: May 18, 1964

Date of Harvest: Oct. 20, 1964

Experimental Design: 8 x 8 Latin Square - Design #4

Size of Plots: 4 Rows x 29' long x 28" between rows

Harvested Area per Plot for Root Yield: 4 Rows x 29' long

Samples for Sucrose Determination: One 10-beet sample taken just prior to harvest from each plot. 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed

Recent Field History:

1961	- Beans	- 300#	- 5-20-20
1962	- Wheat	- 350#	- 5-20-20
		200#	-10-20-10 Topdress
1963	- Beans	- 300#	- 5-20-20

Fertilization of Beet Crop: 700# - 5-20-20 second planting
200# - 5-20-20 sidedress 75# of
Actual Nitrogen

Black Root Exposure:

Leaf Spot Exposure: Light

Other Diseases and Pests:

Soil and Seasonal Conditions: Dry seedbed

Reliability of Test: Good

This test was replanted because of wind damage

Cooperator: F & M Beet Sugar Association - Monitor Sugar Div. Year 1964

Location: Fred Rueggesser Farm, Kawkawlin, Michigan Exp. 4

8 x 8 Latin Square

Variety	Acre Yield		Sucrose %	Clear Juice App. Purity ^b %	Leaf Spot ^c rating	Beets Per 100' No.
	Sugar Recoverable ^a lbs.	Roots Tons				
SL(126x128)msxSP5822-0	6167	20.9	16.77	94.18	3.3	89
SL(129x133)msxSP5822-0	6298	21.3	16.94	93.81	3.0	93
SL(129xSP6121)msxSP5822-0	6412	22.2	16.49	93.89	2.4	92
SL(129xSP6121)msxUT139	5198	18.7	16.14	93.00	3.5	85
SP63194-0	5661	20.3	16.14	93.13	2.0	82
SP63197-0	6071	21.6	16.34	93.08	2.0	89
SL126msxSP5460-0	6216	21.3	16.66	93.96	3.6	94
SP5822-0	6068	20.6	16.86	93.67	1.9	90
General Mean	6012	20.9	16.54	93.59	2.7	89
S. E. Var. Mean	149	.40	.155	.354	.13	2.4
Above as % Gen. Mean	2.5	1.9	0.9	0.4	4.8	2.7
LSD 5% Point	425	1.2	.44	N.S.	0.4	7

Latin Square Analysis			Variance Table					
			Mean Squares					
Source of Variation	D/F							
		Recoverable	Roots	Sucrose	Purity	Spot	Rows	Beets
		Sugar						100'
Between Rows	7	586,552	3.4	.38	.11	.43	78	
Between Columns	7	427,701	6.2	.13	.49	.14	124	
Between Varieties	7	1,257,945	8.8	.81	1.43	4.14	129	
Remainder (Error)	42	177,702	1.3	.19	1.00	.14	44	
Total	63							
Calculated F. Value		7.08**	6.88**	4.22**	N.S.	29.57**	2.91*	

Standard Footnotes ^a, ^b, and ^c on page

Design #2

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Gordon Rogers, Van Wert, Ohio

Cooperation: F&M Beet Sugar Assn. - Buckeye Sugars, Inc.

Date of Planting: April 10, 1964

Date of Harvest: Oct. 27, 1964

Experimental Design: 8 x 8 Latin Square - Design #2

Size of Plots: 4 Rows x 28' Long x 38" between rows

Harvested Area per Plot for Root Yield: 4 Rows x 28' long

Samples for Sucrose Determination: One 10-beet sample taken just prior to harvest from each plot, 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed

Recent Field History: 1961 - Wheat - 300# 6-24-12
1962 - Left in stubble during this year
1963 - Corn 250# 6-24-12 + 80# Actual
Nitrogen as a sidedress

Fertilization of Beet Crop: 400# 12-12-12 plowed down
200# 12-12-12 at planting time

Black Root Exposure: Light

Leaf Spot Exposure: Moderate

Other Diseases and Pests: None

Soil and Seasonal Conditions: Moist seedbed. Below normal moisture thruout growing season.

Reliability of Test: Good.

Cooperator: F & M Beet Sugar Association - Buckeye Sugar Year 1964

Location: Gordon Rogers Farm, Van Wert, Ohio Exp. 2

8 x 8 Latin Square

Variety	Acre Yield		Sucrose %	Clear Juice App. Purity ^b %	Leaf Spot ^c Rating	Beets Per 100'
	Sugar Recoverable ^a lbs.	Roots Tons				
SL(126x128)msxSP5822-0	4833	15.3	17.74	94.30	3.4	89
SL(129x133)msxSP5822-0	4655	14.9	17.93	93.63	3.5	95
SL(129xSP6121)msxSP5822-0	4015	13.5	17.17	92.86	3.1	90
(SP6121xEL61G1)msxSP5822-0	4247	14.5	17.14	92.50	1.6	74
SP63194-0	4282	14.7	17.09	92.32	2.3	89
SP63197-0	4632	15.3	17.71	92.84	2.3	100
SL126msxSP5460-0	4707	15.6	17.41	92.93	3.9	98
SP5822-0	5229	16.3	18.17	94.29	2.1	108
General Mean	4575	15.0	17.54	93.21	2.8	93
S. E. Var. Mean	227	.60	.214	.417	0.18	3.7
Above as % Gen. Mean	5.0	4.0	1.2	0.4	6.4	4.0
LSD 5% Point	648	N.S.	.61	1.19	0.5	10

Latin Square Analysis			Variance Table				
			Mean Squares				
Source of Variation	D/F						Beets
		Recoverable				Leaf	100'
		Sugar	Roots	Sucrose	Purity	Spot	Rows
Between Rows	7	590,722	6.6	.35	1.99	.43	481
Between Columns	7	3,276,577	21.0	1.56	4.86	.14	1540
Between Varieties	7	1,175,359	5.3	1.29	5.39	5.14	810
Remainder (Error)	42	412,732	2.9	.37	1.39	.26	107
Total	63						
Calculated F. Value		2.85*	N.S.	3.53***	3.87***	19.77	7.58***

Standard Footnotes a. b. and c. on page

Design #8

AGRONOMIC EVALUATION TEST

Conducted by: John Niederer

Location: Norbert Wank, Leipsic, Ohio

Cooperation: F&M Beet Sugar Assn., - Buckeye Sugars, Inc.

Date of Planting: May 7, 1964

Date of Harvest: Oct. 28, 1964

Experimental Design: 8 x 8 Latin Square - Design #8

Size of Plots: 4 Rows x 28' long x 36" between rows

Harvested Area per Plot for Root Yield: 4 rows x 28' long

Samples for Sucrose Determination: One 10-beet sample taken just prior to harvest from each plot. 10 beets were taken consecutively in a row where they were growing competitively.

Stand Counts: Harvested beets counted when weighed

Recent Field History: 1961 - Alfalfa - no fertilizer
1962 - Corn - 227# 16-48-0 53# Actual Nitrogen per acre
1963 - Oats - 240# 6-24-12 Broadcast and 96# 6-24-12 at Planting

Fertilization of Beet Crop: 279# 0-46-0 - 155# 0-0-60 and 101# actual nitrogen plowed down with 198# 6-24-12 at planting time

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and Pests:

Soil and Seasonal Conditions: Moist seedbed - Below normal moisture thruout growing season.

Reliability of Test: Good

Cooperator: F & M Beet Sugar Association - Buckeye Sugar Year 1964
 Location: Norbert Wank Farm, Leipsic, Ohio Exp. 8
 8 x 8 Latin Square

Variety	Acre Yield		Sucrose %	Clear Juice App. Purity ^b %	Leaf Spot ^c rating	Beets Per 100' No.
	Sugar Recoverable ^a lbs.	Roots Tons				
SL(126x128)msxSP5822-0	5760	18.8	17.93	92.64		93
SL(129x133)msxSP5822-0	5923	19.0	18.14	93.07		92
SL(129xSP6121)msxSP5822-0	5477	18.6	17.59	91.80		84
(SP6121xEL61G1)msxSP5822-0	5990	19.8	18.13	91.73		96
SP63194-0	4771	16.8	17.45	90.84		89
SP63197-0	4854	16.5	17.66	91.47		86
SL126msxSP5460-0	5707	18.1	18.38	92.83		92
SP5822-0	5333	16.9	18.22	93.31		95
General Mean	5477	18.1	17.94	92.21		91
S. E. Var. Mean	152	.34	.229	.457		2.2
Above as % Gen. Mean	2.8	1.9	1.3	0.5		2.4
LSD 5% Point	434	1.0	.65	1.30		6.0

Latin Square Analysis			Variance Table				
			Mean Squares				
Source of Variation	D/F						Beets
		Recoverable				Leaf	100'
		Sugar	Roots	Sucrose	Purity	Spot	Rows
Between Rows	7	451,004	4.7	.82	2.32		100
Between Columns	7	559,760	5.2	.13	1.91		89
Between Varieties	7	1,717,137	11.4	.94	6.45		134
Remainder (Error)	42	185,321	.9	.42	1.67		38
Total	63						
Calculated F. Value		9.27***	12.26***	2.23*	3.86***		3.50***

Standard Footnotes a., b. and c. on page

Design #6

AGRONOMIC EVALUATION TEST

Conducted by: C. E. Broadwell

Location: Canada & Dominion Sugar Company Experimental Farm
Wallaceburg, Ontario

Cooperation: Canada & Dominion Sugar Co. Ltd.

Date of Planting: May 5, 1964

Date of Harvest: Oct. 4, 1964

Experimental Design: 8 x 8 Latin Square - Design #1

Size of Plots: 4 rows x 30' long x 24" between rows

Harvested Area per Plot for Root Yield: 4 Rows 30'
(2 replications were 28'
plots)

Samples for Sucrose Determination: One 10-beet sample was selected
at random after plot was harvested.

Stand Counts: Harvested beets counted when weighed

Recent Field History: 1962 - Oats - 600# 3-11-11
1963 - Corn - 1000# 14-7-7 + 500# 60%
Muriate + (300# 45% urea plowed
down)

Fertilization of Beet Crop: 700# 5-20-20 at planting time with
200# Ammonium Nitrate broadcast

Black Root Exposure: None

Leaf Spot Exposure: None

Other Diseases and Pests: None

Soil and Seasonal Conditions: Dry to moist seedbed adequate
moisture throughout growing season.

Reliability of Test: Good

Cooperator: C & D Sugar Co., Ltd., F & M Beet Sugar Association Year 1964

Location: C & D Wallaceburg Farm, Wallaceburg, Ontario Exp. 6

8 x 8 Latin Square

Variety	Acre Yield		Sucrose %	Clear Juice App. Purity ^b %	Leaf Spot ^c rating	Beets Per 100' No.
	Sugar	Roots				
	Recoverable ^a Lbs.	Tons				
SL(126x128)msxSP5822-0		25.7	15.2			89
SL(129x133)msxSP5822-0		26.8	15.1			95
SL(129xSP6121)msxSP5822-0		25.8	15.3			92
(SP6121xEL61G1)msxSP5822-0		25.9	15.1			92
SP63194-0		26.1	15.3			94
SP63197-0		25.6	15.3			91
SL126msxSP5460-0		25.4	14.9			91
SP5822-0		25.8	15.4			91
General Mean		25.9	15.2			92
S. E. Var. Mean		.524	.177			2.1
Above as % Gen. Mean		2.0	1.2			2.3
LSD 5% Point		N.S.	N.S.			N.S.

Latin Square Analysis			Variance Table				
			Mean Squares				
Source of Variation	D/F						Beets
		Recoverable				Leaf	100'
		Sugar	Roots	Sucrose	Purity	Spot	Rows
Between Rows	: 7 :		: 16.78 :	: 2.46 :			: 91
Between Columns	: 7 :		: 7.85 :	: .44 :			: 136
Between Varieties	: 7 :		: 1.59 :	: .22 :			: 30
Remainder (Error)	: 42 :		: 2.21 :	: .25 :			: 36
Total	: 63 :						
Calculated F. Value	:		: N.S. :	: N.S. :			: N.S.

Standard Footnotes a., b. and c. on page

Hancock Experimental Farm
Hancock, Wisconsin 54943
College of Agriculture - University of Wisconsin
M. D. Groskopp

1964 Sugar Beet Trials

Soil Type - Plainfield Loamy Sand

pH - 6.5 Avail. P - 140# /A. Avail. K - 180# / Acre

Planting Date - 5/4/64 5 Row plots - each row 30 feet long
28" row width

Seed Source - Dr. G. J. Hogaboam, ARS, Michigan State University,
East Lansing, Michigan

Fertility Treatment

Pre-plant - Broadcast 30#/A. Fert. Borate

At Planting - Banded 3" to side of seed - 500#A 6-13-23

Planted with Belt Seeder @ $1\frac{1}{2}$ " depth - thinned to 12-14 beets per 10
foot of row

Thinned - hand weeded and hoed - 6/11/64

Herbicide - Rep. I & II - 2#/A Eptam

Rep. III & IV - 3#/A Tillam

All beets severely injured by herbicide - Eptam treated

Area suffered 50% plant loss - all plants set back approximately
two weeks growth.

Supplemental Nitrogen - side dressed

6/18 - 250#/A 33-0-0

6/29 - 200#/A 33-0-0

Supplemental Irrigation

11.5 inches of water per acre in 11 applications

Harvested - 2 - 25' lengths of row on 11/3/64 with potato digger.

Topped by hand.

1964 Sugar Beets, Hancock, Wisconsin. Yield in Tons per acre

Treatment		Replicates				Total	Mean
		I	II	III	IV		
(SL129xSP6121)msxUI 159	(U-I)	28.9	28.7	28.2	31.2	117.0	29.2 1
SP63197-0	(Coe)	25.7	28.3	26.0	21.3	101.3	25.3 8
SL(129x133)msxSP5822-0	(F&M)	24.5	24.7	27.0	29.9	106.1	26.5 4
SL(126x128)msxSP5822-0	(F&M)	27.8	25.5	25.8	33.5	112.6	28.1 2
SL126msxSP5460-0	(F&M)	25.3	26.8	24.5	26.6	103.2	25.8 6
SP63194-0	(Coe)	24.9	26.9	22.6	26.9	101.3	25.3 8
(SL129xSP6121)msxSP5822-0	(U-I)	29.1	24.7	26.7	28.5	109.0	27.2 3
SP5822-0	(F&M)	25.5	26.4	24.8	26.1	102.8	25.7 6
General Mean							26.7

Table of Variance (Analyzed as Randomized Complete Block)

Source	D/F	S.S.	M.S.	F. ratio	F. Table	
					0.05	0.01
Treatment	7	58.0	8.28	1.76 ns	2.49	3.64
Replicate	3	22.2	7.40	1.57 ns	3.07	4.87
Error	21	98.4	4.70			
Total	31	178.6				

Sucrose Analysis (by American Crystal Sugar Co. - Rocky Ford, Colo.)

Treatment		Replicates				Total	Mean
		I	II	III	IV		
(SL129xSP6121)msxUI 159	(U-I)	15.9	14.7	14.3	15.0	59.9	14.98 5
SP63197-0	(Coe)	16.7	14.5	15.3	15.0	61.5	15.38 2
SL(129x133)msxSP5822-0	(F&M)	16.2	14.4	14.7	15.7	61.0	15.25 3
SL(126x128)msxSP5822-0	(F&M)	16.0	13.3	14.2	13.2	56.7	14.18 7
SL126msxSP5460-0	(F&M)	16.7	14.6	14.4	14.5	60.2	15.05 4
SP63194-0	(Coe)	15.2	14.9	14.3	14.4	58.8	14.70 6
(SL129xSP6121)msxSP5822-0	(U-I)	14.8	13.6	12.9	13.7	55.0	13.75 8
SP5822-0	(F&M)	15.7	15.6	15.6	15.0	61.9	15.48 1
General Mean							14.84
S.E.M. Treatments		0.2586		LSD 5% Treatment		0.76	
S.E.M. Replication		0.1829		LSD 1% Treatment		1.04	

Table of Variance (Analyzed as Randomized Complete Block)

Source	D/F	S.S.	M.S.	F. ratio	F. Table	
					0.05	0.01
Treatment	7	10.28	1.4685	5.49***	2.49	3.64
Replicate	3	11.96	3.9867	14.89***	3.07	4.87
Error	21	5.62	0.2676			
Total	31	27.86				

$$C.V. = \frac{0.5173}{14.84} - 100 = 3.48\%$$

Myron D. Groskopp, Supt.
Hancock Experimental Farm

F & M Sugar Beet Variety Test - 1964

W.O.A.S. Ridgetown

Variety	BY MACHINE Tons/Acre Roots	BY HAND Tons/Acre Roots	% Sugar	Lbs. Sugar Per Acre	Leaf Spot c.
SL(126x128)msxSP5822-0	16.33	18.09 5	13.63 5	4967 5	3.1
SL(129x133)msxSP5822-0	17.51	19.35 1	13.74 4	5331 2	2.7
(SL129xSP6121)msxSP5822-0	18.28	19.06 2	13.89 2	5349 2	2.4
(SP6121xEL61G1)msxSP5822-0	15.07	18.18 4	13.17 7	4815 7	1.4
SP63194-0	14.78	17.99 6	13.71 4	4988 5	1.7
SP63197-0	11.47	17.11 8	12.94 8	4481 8	1.7
SL126msxSP5460-0	17.31	18.86 3	13.84 2	5260 3	2.7
SP5822-0	16.14	17.76 7	13.50 6	4868 6	1.4
L.S.D. @ 5%	3.82 Tons	N.S.		N.S.	0.6
C. V.	20.7%	11.1%		15.5%	0.2%

Planting Date - April 6, 1964

Plot Size - 3 rows x 20' (1 row x 16' harvested)

Row Width - 24"

Fertilizer - 1400 lbs. of 14-7-7

Previous Crop and Fertilizer

1963 - Oats - 600 lbs. of 3-11-11

1962 - Corn - 1000 lbs. of 14-7-7 + 500 lbs. of 60% Muriate
+ 300 lbs. 45% Urea (plowed down)

Harvest Date - October 5/64

See standard footnote c. page

Section 2. Miscellaneous Hybrids Evaluated for Combining
Ability of Their Male and Female Parents

The hybrids produced in the plastic greenhouse at East Lansing, to evaluate male and female components of hybrids, did not mature seed in time to be planted for evaluation this year. A test of miscellaneous varieties and hybrids was planted in two locations (Merrill, Mich., and Ottawa, Ohio). These two tests met with emergence and other problems such that only the leaf spot data from the Ohio test are considered reliable enough to report.

An experimental hybrid evaluation was made in the nurseries at East Lansing and Beltsville. Twenty-six of the hybrids were furnished by J. O. Gaskill from Fort Collins, while ten of the hybrids were obtained from the F & M. Although not all possible combinations were present in the test, 3 separate analyses of the test made possible an evaluation of 15 different female lines and 3 male lines. Since the Beltsville data on purity and sugar per acre were based on raw juice rather than the clear juice, they are included without analyses as they would not be comparable with data based on the clear juice purity.

Results: Although these data are based on rather small plots, certain female lines are indicated as worthy of further consideration. FC502/2 gave hybrids that were the best in quality (recoverable sugar per ton), nearly the best in root yield, and second only to FC502 in leaf spot resistance. FC502 was much the same as FC502/2 except its root yield was significantly lower. SP581220sl was also of high quality and good yield but gave less resistance to leaf spot to its hybrids. Other lines with hybrids above average in quality with near average or better yield were FC503 and FC503 sub-line.

The excellent quality of hybrids with SP5822-0 as the pollen parent was again confirmed in these tests. SP5822-0 was the best pollen parent for quality of hybrid, for leaf spot resistance, and for yield it was not significantly different from US 401 4n.

The Beltsville test and the Leaf Spot test at East Lansing were under conditions where US 401 was reading from 3 to 5, which is not quite as severe as most other years. The Black Root test at East Lansing was practically free of leaf spot during the entire growing season. Although some black root was observed in the Black Root test, particularly in the inoculated rows, it is felt that there was not enough disease present to make an adequate evaluation for black root resistance. Since there were no significant differences between inoculated and uninoculated rows in either quality or quantity, the average performance of the two rows was used in the data reported in these tests.

Cooperator: F & M Beet Sugar Association - Buckeye Sugar Year 1964

Location: Alphonse Schroeder Farm, Ottawa, Ohio Expt. 12

4 x 5 Rectangular Lattice; Leaf Spot Ratings^C in order of resistance.

Variety	(6 plot averages)	
	Leaf Spot	Rating
SP63180-0 mm		1.2
SP63181-0 mm		1.7
SP6322-0 MM		1.7
SP63194-0 mm		1.7
SP63399-02 mM hybrid		1.8
SP63B8-0 mm		2.2
SL(126x128)msxSP5822-0		2.3
SL(127x128)msxSP5822-0		2.3
SL(127x128)msxUS 401 <u>4n</u>		2.3
SL(129x133)msxSP5822-0		2.3
F62-569H3xSP5822-0		2.3
F61-562H0xSP5822-0		2.3
SP6368-0 mm		2.3
SP60194-01 mm		2.5
SL126xSP5822-0		2.7
SL126xUS 401 <u>4n</u>		2.7
SL(126x128)msxUS 401 <u>4n</u>		2.8
SL(129x133)msxUS 401 <u>4n</u>		2.8
F62-569H3xUS 401 <u>4n</u>		2.8
F61-569H0xSP5822-0		<u>2.8</u>
General Mean		2.28
S.E. Var. Mean		0.18
above as % Gen. Mean		7.9
LSD _{5%} Point		0.5

Source	D/F	M.S.	F ratio
Replications	5	1.6	8.00**
Varieties	19	1.3	6.50**
R x V	<u>95</u>	0.2	
Total	119		

Cooperator F & M Beet Sugar Association, Ottawa, Ohio; USDA
Beltsville, Maryland and East Lansing, Michigan Year 1964

Location Alphonse Schroeder Farm, Ottawa, Ohio; Leaf Spot Nur-
series - Beltsville, Md., and East Lansing, Michigan

Combining ability evaluations for Leaf Spot^c; 5 Females x 2 Males x 3 Loc.

Female	US401 4N Male			Female Average	SP5822-0 Male			Female Average	Female Grand Average
	Md.	Mich.	Ohio		Md.	Mich.	Ohio		
126x128	4.0	4.3	2.8	3.7	3.7	3.7	2.3	3.2	3.5
127x128	4.0	4.7	2.3	3.7	3.3	3.7	2.3	3.1	3.4
129x133	4.3	4.3	2.8	3.8	2.7	3.7	2.3	2.9	3.4
126	4.0	5.3	2.7	4.0	3.0	3.3	2.7	3.0	3.5
F62569H3	4.3	5.0	2.8	4.0	3.3	4.0	2.3	3.2	3.6
Male Aver.	4.1	4.7	2.7	3.8	3.2	3.7	2.4	3.1	

Beltsville, Md. Total = 36.6

East Lansing, Mich. " = 42.0

Ottawa, Ohio " = 25.3

ANALYSIS OF VARIANCE

CT = 35984

Source	D/F	SS _n	MS	F
Total	29	21.57		
Location	2	14.53	7.27	60.58
Varieties	9	4.83	.54	4.50***
Female	4	0.27	.07	
Male	1	4.26	4.26	35.50***
F x M	4	0.30	.08	
L x V	18	2.21	.12	
L x F	8	0.47	.06	
L x M	2	0.78	.39	
L x F x M	8	0.96	.12	

See standard footnote ^c page

Cooperator: USDA - Beltsville, Maryland & East Lansing, Mich. Year 1964

Location: Leaf Spot Nurseries - Beltsville, Md., East Lansing, Mich.

Combining ability evaluations for Leaf Spot^c; 10 Females x 2 Males x 2 Loc.

Female	US401 Md.	4N Male Mich.	Female Average	591101-0 Male Md.	Female Average	Female Grand Average
FC502 (B2)	2.0	3.3	2.71	1.7	3.0	2.5
FC502/2(B2)	3.0	3.0	3.02	2.0	2.3	2.6
FC503 (B3)	3.0	4.0	3.5	3.0	3.0	3.3
FC503 sub(B3)	3.0	4.0	3.5	3.0	3.0	3.3
592087s1(B1)	3.0	3.7	3.4	2.3	3.0	3.0
581220s1(B2)	3.3	4.3	3.8	2.7	3.3	3.4
59200s1	2.7	3.7	3.2	2.0	3.0	2.9
592084s1	3.0	3.7	3.4	2.3	2.7	2.9
592102s1(B1)	2.7	3.7	3.2	1.7	3.0	2.8
592060s1(B1)	3.0	4.0	3.5	2.3	3.0	3.1
Male Average	2.9	3.7	3.3	2.3	2.9	2.6

ANALYSIS OF VARIANCE

CT = 350.46

Source	D/F	SSn	MS	F.
Total	39	15.56		
Location	1	5.63	5.630	63.26(a)***
Varieties	19	8.24	0.434	4.88(a)***
Female	9	3.14	.349	3.92(a)**
Male	1	4.77	4.770	53.60(a)***
F x M	9	0.33	.037	N.S.
L x V (a)	19	1.69	0.089	
L x F (b)	9	1.06	.118	2.11(d) N.S.
L x M (c)	1	.13	.130	2.32(d) N.S.
L x F x M (d)	9	.50	.056	

General Mean = 3.0
 S. E. Var. Mean = .15
 Above as % Gen. Mean = 5.0
 LSD(female) 5% Point = .5

See standard footnote ^c page

Cooperator: USDA - Beltsville, Maryland & East Lansing, Mich. Year 1964

Location: Leaf Spot Nurseries - Beltsville, Md., East Lansing, Mich.

Combining ability evaluations for Leaf Spot^c; 6 Females x 3 Males x 2 Loc.

Female	Male F.			Male F.			Male F.			Female Grand Average
	US401	4 ⁿ	Ave.	5822-0	Ave.	591101-0	Ave.			
	Md. Mich.			Md. Mich.		Md. Mich.				
FC502(B2)	2.0	3.3	2.7	1.7	2.0	1.9	1.7	3.0	2.4	2.3 1
FC502/2(B2)	3.0	3.0	3.0	1.7	2.3	2.0	2.0	2.3	2.2	2.4 2
FC503(B3)	3.0	4.0	3.5	3.3	3.0	3.2	3.0	3.0	3.0	3.2
FC503(subline B+3)	3.0	4.0	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.2
592087s1	3.0	3.7	3.4	2.0	2.3	2.2	2.3	3.0	2.7	2.7
581220s1	3.3	4.3	3.8	3.0	3.0	3.0	2.7	3.3	3.0	3.3
Male Average	2.9	3.7	3.3	2.5	2.6	2.5	2.5	2.9	2.7	

ANALYSIS OF VARIANCE

CT = 290.13

Source	D/F	SSn	MS	F.
Total	35	14.73		
Location	1	2.16	2.160	23.74 (b&d)***
Varieties	17	10.51	0.618	5.11 (a)***
Female	5	5.79	1.158	9.57 (b&d)***
Male	2	4.00	2.000	5.80 (c) N.S.
F x M	10	.72	.072	
L x V (a)	17	2.06	0.121	
L x F (b)	5	.53	.106	1.26 N.S.
L x M (c)	2	.69	.345	4.11 (d)*
L x F x M (d)	10	.84	.084	
Pooled (b&d)	15	1.37	.091	
General Mean		= 2.8		
S. E. Var. Mean		= 0.12		
Above as % Gen. Mean		= 4.3		
LSD (female) 5% Point		= 0.4		

See standard footnote ^c. page

Conducted by: G. J. Hogaboam and D. L. Mumford

Location: Crops Farm, Michigan State University, East Lansing, Michigan

Cooperation: Crops Science Department, Michigan State University

Date of Planting: Leaf Spot - May 5, 1964; Black Root - May 21, 1964

Date of Harvest: Leaf Spot - Oct. 29, 1964 (177 day growing period)
Black Root - Oct. 26, 1964 (158 day growing period)

Experimental Design: 6 x 6 Triple Lattice

Size of Plots: Leaf Spot - 1 row 20' long, 28" apart; Black Root - 2 rows
(one inoculated, one uninoculated) 20' long, 28" apart.

Harvested Area per Plant for Root Yield: Entire plot

Samples for Sucrose Determination: Entire plot

Stand Counts: Beets counted in row prior to harvest.

Recent Field History: Continuous beets

Fertilization of Beet Crop: None in 1964

Black Root Exposure: Light in both tests

Leaf Spot Exposure: Inoculated Leaf Spot nursery June 22 and again on July 6 with powdered inoculum applied with a back mounted, motor powered duster which applied the dust with water to stick it to the leaves. Leaf Spot readings made August 27 and Sept. 14. US 401 was reading a "3" to a "4" in the August reading; and a "4" to "5" in the Sept. reading. Practically no Leaf Spot developed in Black Root test. It was never inoculated with Leaf Spot.

Other Diseases and Pests: Very small amount of Rhizoctonia.

Soil and Seasonal Conditions: For Leaf Spot nursery good rains following planting with excellent emergence. Black Root nursery irrigated on May 29, June 1, and June 5. Estimated nearly 100% emergence by June 8. Fairly dry summer.

Reliability of Test: Good for size of plot.

1964 E. Lansing Nursery Test of Experimental Hybrids; Quality = Sugar
Recoverable in Pounds per Ton.

Leaf Spot Test - 3 repl., plots 1 row 20 ft. long
Black Root Test- 3 repl., plots 2 rows 20 ft. long

(3 Plot Averages)

FEMALE PARENT	MALE PARENT						Female Averages		
	SP5822-0 MM:US		401 MMMM		SP591101-Omm		Anal.	Anal.	Anal.
	Test	Test	Test	Test	Test	Test	A	B	C
	LS	BR	LS	BR	LS	BR	Aver.	Aver.	Aver.
SL 126x128	: 295	316	: 306	298	:	:	: 303.8	:	:
SL 127x128	: 313	305	: 277	294	:	:	: 297.3	:	:
SL 129x133	: 300	314	: 298	296	:	:	: 302.0	:	:
SL 126	: 301	293	: 284	300	:	:	: 294.5	:	:
F62-569H3	: 286	305	: 269	287	:	:	: 286.8	:	:
FC502(B ₂)	: 334	328	: 292	304	: 338	323	: 314.5	: 314.3	: 319.8
FC502/2(B ₂)	: 346	331	: 306	283	: 340	331	: 316.5	: 315.0	: 322.8
FC503(B ₃)	: 315	332	: 297	281	: 314	292	: 306.3	: 296.0	: 305.2
FC503sub.(B ₃₊)	: 312	325	: 302	306	: 306	278	: 311.3	: 298.0	: 304.8
SP592087s1(B ₁)	: 317	313	: 278	294	: 313	298	: 300.5	: 295.8	: 302.2
SP581220s1(B ₂)	: 332	315	: 306	299	: 316	319	: 313.0	: 310.0	: 314.5
SP592000s1(B ₁)	:	:	: 284	279	: 301	305	:	: 292.3	:
SP592084s1(B ₂)	:	:	: 263	270	: 299	301	:	: 283.3	:
SP592102s1(B ₁)	:	:	: 292	298	: 317	306	:	: 303.3	:
SP592060s1(B ₁)	:	:	: 302	272	: 301	269	:	: 286.0	:
Male Averages						female LSD _{5%}	14.7	NS	12.2
Analysis A	: 314.9		: 293.5						
Analysis B			: 290.4		308.4				
Analysis C	: 325.0		: 295.7		314.0 male LSD _{5%}			Anal. C=8.6	

Test Averages: Leaf Spot 303.9
Black Root 301.3

Analysis A; 11 females x 2 males x 2 tests
Analysis B; 10 females x 2 males x 2 tests
Analysis C; 6 females x 3 males x 2 tests

	Analysis A			Analysis B			Analysis C		
	D/F	M.S.	F ratio	D/F	M.S.	F ratio	D/F	M.S.	F ratio
TESTS	: 1	: 64	: NS	: 1	: 632	: 6.05 _a	: 1	: 349	: NS
VARIETIES	: 21	: 482	: 4.82 _a **	: 19	: 525	: 5.03 _a **	: 17	: 551	: 5.54 _a **
Females	: 10	: 342	: 3.42 _a **	: 9	: 493	: NS _e	: 5	: 454	: 4.56 _a **
Males	: 1	: 504	: 50.42 _a **	: 1	: 3222	: 12.49 _a **	: 2	: 2635	: 26.48 _a **
F x M (e	: 10	: 166	: NS	: 9	: 258	: 2.47 _a	: 10	: 183	: NS
TEST X VAR(a	: 21	: 100	:	: 19	: 104	:	: 17	: 100	:
T x F (b	: 10	: 102	: NS	: 9	: 125	: NS	: 5	: 40	: NS
T x M (c	: 1	: 0	: NS	: 1	: 189	: NS	: 2	: 148	: NS
T x F x M(d	: 10	: 109	:	: 9	: 75	:	: 10	: 119	:
TOTAL	: 43	:	:	: 39	:	:	: 35	:	:

1964 E. Lansing Nursery Test of Experimental Hybrids; Percent Sucrose.

Leaf Spot Test - 3 repl., plots 1 row 20 ft. long
Black Root Test- 3 repl., plots 2 rows 20 ft. long

(3 Plot Averages)

FEMALE PARENT	MALE PARENT						Female Averages		
	: SP5822-0 MM:US 401 MMMM : SP591101-Omm:						Anal.	Anal.	Anal.
	: Test : Test : Test :						A	B	C
	LS	BR	LS	BR	LS	BR	Aver.	Aver.	Aver.
SL 126x128	:16.7	17.3	: 17.3	17.0	:	:	: 17.08	:	:
SL 127x128	:17.4	17.1	: 16.2	16.6	:	:	: 16.83	:	:
SL 129x133	:17.0	17.4	: 16.8	16.9	:	:	: 17.03	:	:
SL 126	:16.9	16.7	: 16.3	16.8	:	:	: 16.68	:	:
F62-569H3	:16.6	17.2	: 15.6	16.6	:	:	: 16.50	:	:
FC502(B ₂)	:18.5	18.0	: 16.9	17.2	: 18.8	18.1	: 17.65	: 17.75	: 17.92
FC502/2(B ₂)	:18.7	18.3	: 17.2	16.2	: 18.8	18.0	: 17.60	: 17.55	: 17.87
FC503(B ₃)	:17.8	18.5	: 17.2	16.5	: 17.8	16.9	: 17.50	: 17.10	: 17.45
FC503sub.(B ₃ *)	:17.5	17.9	: 17.3	17.3	: 17.4	16.3	: 17.50	: 17.08	: 17.28
SP592087s1(B ₁)	:17.4	17.4	: 15.8	16.6	: 17.4	16.8	: 16.80	: 16.65	: 16.90
SP581220s1(B ₂)	:18.1	17.5	: 17.3	17.0	: 17.9	17.6	: 17.48	: 17.45	: 17.57
SP592000s1(B ₁)	:	:	: 16.4	16.1	: 17.1	17.1	:	: 16.68	:
SP592084s1(B ₂)	:	:	: 16.0	15.9	: 17.1	17.0	:	: 16.50	:
SP592102s1(B ₁)	:	:	: 16.6	16.9	: 17.7	17.2	:	: 17.10	:
SP592060s1(B ₁)	:	:	: 17.2	15.8	: 17.3	15.7	:	: 16.50	:
Male Averages							female LSD 5%	.56	: 0.63: 0.49:
Analysis A	: 17.54			16.75	:				
Analysis B	:	:	16.67			17.40	:		
Analysis C	: 17.97			16.88	:	17.65	male LSD 5%	Anal. C=0.35	

Test Averages: Leaf Spot 17.21
Black Root 17.03

Analysis A; 11 Females x 2 Males x 2 Tests
Analysis B; 10 Females x 2 Males x 2 Tests
Analysis C; 6 Females x 3 Males x 2 Tests

	Analysis A				Analysis B				Analysis C		
	D/F	M.S.	F ratio		D/F	M.S.	F ratio		D/F	M.S.	F ratio
TESTS	: 1	:0.050	: NS	:	: 1	:2.020	:11.22*	:	: 1	:0.900	: 5.56*
VARIETIES	:21	:0.799	: 5.34*	:	:19	:0.849	: 4.72*	:	:17	:0.897	: 5.54*
Females	: 10	: 0.680	: 4.66*	:	: 9	: 0.804	: 4.47*	:	: 5	: 0.866	: 5.35*
Males	: 1	: 6.800	: 46.58*	:	: 1	: 0.533	: NS	:	: 2	: 3.785	: 23.36*
F x M	: 10	: 0.317	: NS	:	: 9	: 0.396	: NS	:	: 10	: 0.335	: NS
Test x VAR(a)	:21	:0.146	:	:	:19	:0.180	:	:	:17	:0.162	:
T x F (b)	: 10	: 0.161	: NS	:	: 9	: 0.240	: NS	:	: 5	: 0.102	: NS
T x M (c)	: 1	: 0.000	: NS	:	: 1	: 0.440	: NS	:	: 2	: 0.400	: NS
T x F x M(d)	: 10	: 0.146	:	:	: 9	: 0.091	:	:	: 10	: 0.145	:
TOTAL	:43	:	:	:	:39	:	:	:	:35	:	:

1964 E. Lansing Nursery Test of Experimental Hybrids; Clear Juice Purity

Leaf Spot Test - 3 repl., 1 row 20 ft. long
Black Root Test- 3 repl., 2 rows 20 ft. long

(3 Plot Averages)

FEMALE PARENT	MALE PARENT						Female Averages		
	SP5822-0 MM:US 401 MMM		SP591101-Omm		Anal.		Anal.	Anal.	
	Test		Test		Test		A	B	C
	LS	BR	LS	BR	LS	BR	Aver.	Aver.	Aver.
SL 126x128	:94.3	95.8	:94.5	94.1	:	:	:94.68	:	:
SL 127x128	:95.0	94.7	:93.0	94.6	:	:	:94.33	:	:
SL 129x133	:94.4	95.0	:94.5	93.9	:	:	:94.45	:	:
SL 126	:94.5	94.2	:94.0	94.9	:	:	:94.40	:	:
F62-569H3	:93.7	94.4	:93.3	93.6	:	:	:93.75	:	:
FC502(B ₂)	:95.3	95.7	:93.5	94.6	:95.1	95.1	:94.78	:94.58	:94.88
FC502/2(B ₂)	:96.4	95.5	:94.6	93.6	:95.8	95.0	:95.03	:94.75	:95.15
FC503(B ₃)	:94.2	95.3	:94.0	93.0	:94.1	93.7	:94.13	:93.70	:94.05
FC503sub.(B ₃₊)	:94.9	95.2	:93.9	94.4	:94.3	92.7	:94.60	:93.83	:94.23
SP592087sl(B ₁)	:95.3	95.4	:93.4	94.4	:95.1	94.2	:94.63	:94.28	:94.63
SP581220sl(B ₂)	:95.7	95.2	:94.5	94.0	:94.2	95.4	:94.85	:94.53	:94.83
SP592000sl(B ₁)	:	:	:93.8	93.1	:94.3	94.6	:	:93.95	:
SP592084sl(B ₂)	:	:	:91.8	92.7	:93.9	94.3	:	:93.18	:
SP592102sl(B ₁)	:	:	:94.1	94.1	:95.4	94.8	:	:94.60	:
SP592060sl(B ₁)	:	:	:93.6	93.2	:93.6	92.9	:	:93.33	:
Male Averages							female LSD _{5%}	NS	: 0.84: 0.74:
Analysis A	: 95.00			94.01	:				
Analysis B	:	:	:	93.72	:	94.43	:		
Analysis C	: 95.34			93.99	:	94.56 male LSD _{5%}	Anal. C= 0.53		

Test Averages: Leaf Spot 94.3
Black Root 94.4

Analysis A; 11 Females x 2 Males x 2 Tests
Analysis B; 10 Females x 2 Males x 2 Tests
Analysis C; 6 Females x 3 Males x 2 Tests

	Analysis A				Analysis B				Analysis C		
	D/F	M.S.	F ratio		D/F	M.S.	F ratio		D/F	M.S.	F ratio
TESTS	: 1	:0.480	: NS	:	: 1	:0.250	: NS	:	: 1	:0.100	: NS
VARIETIES	:21	:0.897	: 2.79 _a *	:	:19	:1.102	: 3.38 _a **	:	:17	:1.099	: 2.95 _a *
Females	: 10:	0.511:	NS	:	: 9:	1.251:	3.84 _a **	:	: 5:	1.044:	2.81 _a *
Males	: 1:	10.800:	33.54 _a **	:	: 1:	5.040:	15.46 _a **	:	: 2:	5.515:	14.83 _a **
F x M	: 10:	0.292:	NS	:	: 9:	0.516:	NS	:	: 10:	0.243:	NS
TEST X VAR(a)	:21	:0.322	:	:	:19	:0.326	:	:	:17	:0.372	:
T x F (b)	: 10:	0.276:	NS	:	: 9:	0.292:	NS	:	: 5:	0.326:	NS
T x M (c)	: 1:	0.020:	NS	:	: 1:	0.230:	NS	:	: 2:	0.225:	NS
T x F x M (d)	:10:	0.399:	:	:	: 9:	0.370:	:	:	: 10:	0.424:	:
TOTAL	:43	:	:	:	:39	:	:	:	:35	:	:

1964 E. Lansing Nursery Test of Experimental Hybrids; Tons/Acre Yield.

Leaf Spot Test - 3 repl., plots 1 row 20 ft. long
Black Root Test- 3 repl., plots 2 rows 20 ft. long

(3 Plot Averages)

FEMALE PARENT	MALE PARENT						Female Averages		
	SP5822-0 MM:US		401 MMM		SP591101-Omm		Anal.	Anal.	Anal.
	Test		Test		Test		A	B	C
	LS	BR	LS	BR	LS	BR	Aver.	Aver.	Aver.
SL 126x128	:13.1	14.1	: 12.9	14.5	:	:	: 13.65	:	:
SL 127x128	:15.1	14.9	: 13.5	12.6	:	:	: 14.03	:	:
SL 129x133	:15.9	16.7	: 13.8	15.4	:	:	: 15.45	:	:
SL 126	:14.6	15.9	: 15.8	15.4	:	:	: 15.43	:	:
F62-569H3	:13.5	16.2	: 14.5	14.1	:	:	: 14.58	:	:
FC502(B ₂)	:13.6	13.9	: 13.2	12.5	: 11.8	10.9	: 13.30	: 12.10	: 12.65
FC502/2(B ₂)	:15.4	14.0	: 15.4	15.9	: 11.9	12.0	: 15.18	: 13.80	: 14.10
FC503(B ₃)	:17.0	13.4	: 15.7	15.5	: 12.2	11.0	: 15.40	: 13.60	: 14.13
FC503sub.(B ₃₊)	:15.2	12.3	: 14.9	14.2	: 10.1	11.6	: 14.15	: 12.70	: 13.05
SP592087sl(B ₁)	:18.1	12.3	: 12.4	14.6	: 12.1	9.3	: 14.35	: 12.10	: 13.13
SP581220sl(B ₂)	:13.4	14.8	: 15.3	15.6	: 12.3	10.9	: 14.77	: 13.53	: 13.72
SP592000sl(B ₁)	:	:	: 18.1	15.4	: 14.9	11.0	:	: 14.85	:
SP592084sl(B ₂)	:	:	: 13.7	11.7	: 11.6	10.6	:	: 11.90	:
SP592102sl(B ₁)	:	:	: 14.6	13.5	: 10.2	9.7	:	: 12.00	:
SP592060sl(B ₁)	:	:	: 15.9	13.6	: 11.3	10.6	:	: 12.85	:
Male Averages							female LSD _{5%} NS	: 1.48	NS
Analysis A	: 14.70		14.44	:					
Analysis B	:		14.59		11.30	:			
Analysis C	: 14.45		14.60		11.34	male LSD _{5%} Anal. C=1.44			

Test Averages: Leaf Spot 13.97
Black Root 13.34

Analysis A; 11 Females x 2 Males x 2 Tests
Analysis B; 10 Females x 2 Males x 2 Tests
Analysis C; 6 Females x 3 Males x 2 Tests

	Analysis A			Analysis B			Analysis C		
	D/F	M.S.	F ratio	D/F	M.S.	F ratio	D/F	M.S.	F ratio
TESTS	: 1	:0.280	: NS	: 1	:7.660	: 7.67*	: 1	:6.500	: NS
VARIETIES	:21	:1.747	: NS	:19	:7.946	: 7.96*	:17	:6.018	: 3.08*
Females	: 10	: 2.233	: NS	: 9	: 3.826	: 3.83*	: 5	: 2.232	: NS
Males	: 1	: 0.740	: NS	: 1	:107.910	:108.13*	: 2	:40.600	:20.76*
F x M	: 10	: 1.362	: NS	: 9	: 0.960	: NS	: 10	: 0.994	: NS
TEST x VAR(a)	:21	:1.942	:	:19	:0.998	:	:17	:1.956	:
T x F (b)	: 10	: 1.574	: NS	: 9	: 1.128	: NS	: 5	: 1.126	: NS
T x M (c)	: 1	:1.960	: NS	: 1	: 0.042	: NS	: 2	: 3.755	: NS
T x F x M(d)	: 10	: 2.308	:	: 9	: 0.932	:	: 10	: 2.012	:
TOTAL	:43	:	:	:39	:	:	:35	:	:

1964 Beltsville Test of Experimental Hybrids; Percent Sucrose

Leaf Spot Nursery - 3 repl., plots 1 row 20 ft. long

(3 plot averages)

FEMALE PARENT	MALE PARENT			Female Averages		
	SP5822-0 MM:US	401 MMMM	SP591101-Omm	Anal.	Anal.	Anal.
	A	B	C			
SL 126x128	12.20	12.30		12.25		
SL 127x128	12.77	12.13		12.45		
SL 129x133	12.77	12.43		12.60		
SL 126	12.97	12.00		12.49		
F62-569H3	12.47	11.57		12.02		
FC502(B ₂)	14.43	12.40	14.23	13.42	13.32	13.69
FC502/2(B ₂)	14.20	12.57	14.43	13.39	13.50	13.73
FC503(B ₃)	13.53	12.53	13.30	13.03	12.92	13.12
FC503sub.(B ₃ ±)	13.63	12.23	13.73	12.93	12.98	13.20
SP592087s1(B ₁)	13.00	12.70	12.90	12.85	12.80	12.87
SP581220s1(B ₂)	13.63	12.10	12.67	12.87	12.39	12.80
SP592000s1(B ₁)		12.13	12.77		12.45	
SP592084s1(B ₂)		11.60	12.53		12.07	
SP592102s1(B ₁)		12.23	13.07		12.65	
SP592060s1(B ₁)		12.93	12.03		12.48	
Male Averages				Female LSD _{5%}	NS	NS
Analysis A	13.24	12.27				
Analysis B		12.34	13.17			
Analysis C	13.74	12.42	13.54	male LSD _{5%}	Anal. C = 0.53	

Analysis A; 11 females x 2 males

Analysis B; 10 females x 2 males

Analysis C; 6 females x 3 males

	Analysis A			Analysis B			Analysis C		
	D/F	M.S.	F ratio	D/F	M.S.	F ratio	D/F	M.S.	F ratio
Females	10	0.3890	NS	9	0.3866	NS	5	0.4751	NS
Males	1	5.1459	24.72**	1	3.3949	10.16*	2	3.0248	17.71**
F x M	10	0.2082		9	0.3343		10	0.1708	

1964 Beltsville Test of Experimental Hybrids; Tons/Acre Yield of Roots.

Leaf Spot Nursery - 3 repl., plots 1 row 20 ft. long

(3 Plot Averages)									
FEMALE PARENT	MALE PARENT					Female Averages			
	SP5822-0	MM:US 401	MTMM:SP591101	-Omm:	Anal.:	Anal.:	Anal.:		
					A	B	C		
SL 126x128	: 18.35	: 15.01	:	:	: 16.68:	:	:		
SL 127x128	: 21.53	: 16.43	:	:	: 18.98:	:	:		
SL 129x133	: 21.56	: 13.87	:	:	: 17.72:	:	:		
SL 126	: 15.41	: 17.01	:	:	: 16.21:	:	:		
F62-569H3	: 20.15	: 15.65	:	:	: 17.86:	:	:		
FC502(B ₂)	: 24.18	: 23.03	: 17.39	:	: 23.61:	20.21:	21.53:		
FC502/2(B ₂)	: 21.58	: 22.38	: 19.08	:	: 21.98:	20.73:	21.01:		
FC503(B ₃)	: 18.82	: 19.47	: 16.23	:	: 19.15:	17.85:	18.17:		
FC503sub.(B ₃₊)	: 18.84	: 23.52	: 15.81	:	: 21.18:	19.67:	19.39:		
SP592087s1(B ₁)	: 21.42	: 21.54	: 17.70	:	: 21.48:	19.62:	20.22:		
SP581220s1(B ₂)	: 22.72	: 21.56	: 16.64	:	: 22.14:	19.10:	20.31:		
SP592000s1(B ₁)	:	: 23.63	: 19.00	:	:	21.32:	:		
SP592084s1(B ₂)	:	: 21.07	: 16.88	:	:	18.98:	:		
SP592102s1(B ₁)	:	: 22.14	: 19.82	:	:	20.98:	:		
SP592060s1(B ₁)	:	: 20.87	: 16.14	:	:	18.51:	:		
Male Averages					Female LSD _{5%}	NS	NS	NS	
Analysis A	: 20.41	: 19.04	:	:					
Analysis B	:	: 21.92	: 17.47	:					
Analysis C	: 21.26	: 21.92	: 17.14	male LSD _{5%}	Anal. C = 1.65				

Analysis A; 11 females x 2 males

Analysis B; 10 females x 2 males

Analysis C; 6 females x 3 males

	Analysis A				Analysis B				Analysis C		
	D/F	M.S.	F ratio		D/F	M.S.	F ratio		D/F	M.S.	F ratio
Females	: 10	: 11.7748	: NS	:	: 9	: 2.5136	: NS	:	: 5	: 4.2723	: NS
Males	: 1	: 9.0240	: NS	:	: 1	: 99.1015	: 88.58**	:	: 2	: 39.0942	: 23.82**
F x M	: 10	: 6.2695	:	:	: 9	: 1.1188	:	:	: 10	: 1.6415	:

1964 Beltsville, Maryland Nursery Test of Experimental Hybrids

Percent Purity (Average of 3 determinations)

Female Parent: Male Parent
5822-0:US 4n 401:591101-0:Female Ave.

SL 126	:	78.43	76.76	:	77.59
(126 X 128)	:	77.53	76.52	:	77.03
(127 X 128)	:	77.87	76.98	:	77.43
(129 X 133)	:	78.28	76.77	:	77.53
F62-569H3	:	78.23	75.77	:	77.00
FC 502 (B ₂)	:	81.51	76.40	78.64	: 78.85
FC 502/2 (B ₂)	:	79.18	76.16	77.57	: 77.64
FC 503 (B ₃)	:	77.47	75.05	77.00	: 76.51
FC 503 (Sub-					
line B ₃ ⁺)	:	77.40	75.51	77.29	: 76.73
592087s ₁	:	79.59	78.74	78.34	: 78.89
581220s ₁	:	78.67	78.66	77.22	: 78.18
592000s ₁	:		76.63	76.42	: 76.53
592084s ₁	:		75.80	77.50	: 76.65
592102s ₁ (B ₁)	:		77.26	80.01	: 78.63
592060s ₁ (B ₁)	:		78.68	76.85	: 77.76

Male Averages: 78.56 76.78 77.68

SP 6322-0 80.24
US 401 77.21

1964 Beltsville, Maryland Nursery Test of Experimental Hybrids

Gross Sugar in Pounds/Acre (Based on total of 3 - 20 ft. rows)

Female Parent:	Male Parent		Female
	5822-0:US	401:591101-0:	
	<u>4n</u>		Ave.
SL 126	: 3997	: 4082	: 4039
(126 X 128)	: 4477	: 3692	: 4085
(127 X 128)	: 5499	: 3985	: 4742
(129 X 133)	: 5506	: 3448	: 4477
F62-569H3	: 5025	: 3621	: 4323
FC 502 (B ₂)	: 6978	: 5711	: 4949
FC 502/2 (B ₂)	: 6129	: 5626	: 5506
FC 503 (B ₃)	: 5093	: 4879	: 4317
FC 503 (Sub-			
line B ₃ ±)	: 5135	: 5753	: 4341
592087s ₁	: 5569	: 5471	: 4567
581220s ₁	: 6193	: 5217	: 4216
592000s ₁	:	: 5732	: 4853
592084s ₁	:	: 4888	: 4230
592102s ₁ (B ₁)	:	: 5415	: 5181
592060s ₁ (B ₁)	:	: 5397	: 3883
Male Averages:	(5418)	: 4861	: 4604
SP 6322-0			6517
US 401			4980

1964 Beltsville, Maryland Nursery Tests of Experimental Hybrids

Beets per 100 ft. of row. (Based on total of 3 - 20 ft. rows.)

		Male Parent					
Female Parent:		US 401: 591101-0:				Female	
		<u>4n</u>				Ave.	
SL 126	:	69	:	80	:	:	75
(126 X 128)	:	72	:	78	:	:	75
(127 X 128)	:	96	:	76	:	:	86
(129 X 133)	:	80	:	69	:	:	75
F62-569H3	:	85	:	78	:	:	82
FC 502 (B ₂)	:	93	:	87	:	67	82
FC 502/2 (B ₂)	:	74	:	89	:	78	80
FC 503 (B ₃)	:	72	:	76	:	69	72
FC 503 (Sub-							
line B _{3±})	:	80	:	89	:	87	85
592087s ₁	:	74	:	83	:	69	75
581220s ₁	:	98	:	83	:	80	87
592000s ₁	:		:	80	:	67	74
592084s ₁	:		:	87	:	72	80
592102s ₁ (B ₁)	:		:	70	:	80	75
592060s ₁ (B ₁)	:		:	83	:	57	70
Male Averages:		81	:	81	:	73	
SP 6322-0							80
US 401							89

AGRONOMIC EVALUATION TEST, 1964

Miscellaneous Variety Test

Conducted by: Richard Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: George Richm Farm, Old Fort, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: April 16, 1964

Date of Harvest: October 28, 1964

Experimental Design: Simple Rectangular Lattice

Size of Plots: 1 row x 22 feet planted

Harvest Area per Plot for Root Yield: 1 row x 18 feet

Samples for Sucrose Determination: 1 sample per plot: 1 row x 18 feet

Stand Counts and Bolter Counts: Beets counted in the laboratory for harvest stand. No bolters developed.

Recent Field History: Corn (1963)

Fertilization of Beet Crop: 100 pounds N, 70 pounds P_2O_5 and 250 pounds K_2O plowed down.
150 pounds 6-24-12 in row.

Leaf Spot Exposure: Moderate. September development

Black Root Exposure: Very mild

Curly Top Exposure: None noted

Other Diseases: Rhizoctonia crown rot caused small loss in stand

Soil and Seasonal Conditions: Very good moisture for germination and seedling growth. Dry weather prevailed through summer and fall except for showers in August.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush,
R. K. Oldemeyer and D. L. Sunderland

Miscellaneous Variety Test

Location: George Riehm Farm, Old Fort, Ohio

Year: 1964

(Results given as 8 plot averages)

Variety	Acre Yield				Thin Juice App. Purity (%)	Leaf ^(d) Spot (10/11/64)	Beets ^(e) per 100 ft. (No.)
	Sugar		Roots (tons)	Sucrose (%)			
	Recover- ^(a)						
	able (lbs.)	Gross (lbs.)					
SP6322-0	6773	7449	21.681	17.186	95.791	0.6	115
SP5822-0	6323	7130	19.993	17.841	94.513	0.4	133
SP63181-0	6106	7035	21.132	16.658	93.558	0.6	126
SP6368-0	6036	6743	19.574	17.234	95.002	0.8	124
SP63194-0	5737	6524	19.025	17.156	94.134	1.0	117
SP63180-0	5619	6414	18.447	17.392	93.936	0.1	129
SP63197-0	5556	6363	18.457	17.244	93.807	0.6	113
53B8-0	5281	6027	18.138	16.628	94.005	0.8	143
General Mean ^(f)	7046	7961	22.94	17.36	94.42	-	-
S.E. Variety Mean (Sm)	-	363.00	2.1107	.1685	.4431	-	-
Sm/Gen. Mean (%)	-	4.56	4.45	0.97	0.47	-	-
LSD 5% pt.	894 ^(b)	1010	2.84	0.74	1.23	-	-

Variance Table^(c)

Source of Variance	DF	Mean Squares		
		Roots ^(h) (lbs.)	Sucrose (%)	Purity (%)
Replicates	7	162.5300	.7843	3.3600
Component (a)	30	13.5633	.6393	1.5330
Component (b)	10	23.0080	.3250	1.1110
Blocks (eliminating varieties)	40	15.9245	.5608	1.4275
Varieties (ignoring blocks)	29	284.1531	1.5272 ^(g)	3.4855
Error (intra-block)	163	40.4961 ^(g)	.2272 ^(g)	1.6062 ^(g)
Error (random block)	203	35.6544 ^(g)	.2929	1.5710 ^(g)
Total	239	69.5230	.4571	1.7344
Calculated F value		7.97**	6.72**	2.22**

(a, (b, (c See page 155.

(d 0 = no evidence of disease, 10 = complete necrosis due to leaf spot

(e Harvest stand

(f General mean for 30 varieties in test

(g Error term used

(h Pounds per plot

AGRONOMIC EVALUATION TEST, 1964

Miscellaneous Variety Test

Conducted by: Richard Zielke, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Glen Haas Farm, Fremont, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: May 10, 1964

Date of Harvest: October 14, 1964

Experimental Design: Simple Rectangular Lattice

Size of Plots: 1 row x 22 feet planted (30-inch rows)

Harvest Area per Plot for Root Yield: 1 row x 18 feet

Samples for Sucrose Determination: 1 sample per plot; 1 row x 18 feet

Stand Counts and Bolter Counts: Beets counted in the laboratory for harvest stand. No bolters developed.

Recent Field History: Corn (1963)

Fertilization of Beet Crop: 600 pounds 0-25-25 plowed down
60 pounds N as anhydrous ammonia sidedressed on
June 30.
175 pounds 6-24-12 in row

Leaf Spot Exposure: None noted

Black Root Exposure: Mild to moderate

Curly Top Exposure: None noted

Other Diseases: None noted

Soil and Seasonal Conditions: Very slow germination and seedling growth due to lack of rain. Extremely dry weather throughout the summer except for showers in August.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush,
R. K. Oldemeyer and D. L. Sunderland
Miscellaneous Variety Test
 Location: Glen Haas Farm, Fremont, Ohio Year: 1964

(Results given as 8 plot averages)

Variety	Acre Yield				Thin Juice App. Purity	Beets (e) per 100 ft. (No.)
	Sugar					
	Recover-(a)					
	able (lbs.)	Gross (lbs.)	Roots (tons)	Sucrose (%)		
SP6322-0	4219	4791	14.02 3	17.09 3	94.20 1	108
53B8-0	4046	4814	14.49 1	16.61 3	92.10 7	109
SP5822-0	4021	4655	13.66 4	17.05 3	93.29 4	112
SP6368-0	3980	4709	14.20 2	16.58 8	92.35 5	119
SP63197-0	3949	4569	13.45 5	16.99 4	93.33 3	97
SP63181-0	3381	4152	12.54 6	16.56 8	90.77 6	95
SP63194-0	3337	3858	11.31 8	17.06 3	93.36 3	100
SP63180-0	3233	3840	11.34 8	16.93 5	92.15 7	97
General Mean (f)	4156	4857	14.36	16.92	92.87	-
S.E. Variety Mean (Sm)	-	228.04	1.3599	.2409	.4795	-
Sm/Gen. Mean (%)	-	4.69	4.58	1.01	0.52	-
LSD 5% pt.	543 (b)	635	2.68	0.47	1.37	-

Variance Table^(c)

Source of Variance	DF	Mean Squares		
		Roots (lbs.) ^(h)	Sucrose (%)	Purity (%)
Replicates	7	115.1385	1.3500	5.7514
Component (a)	30	33.8023	.3383	2.1793
Component (b)	10	10.5600	.2060	2.8900
Blocks (eliminating varieties)	40	27.9918	.3053	2.3570
Varieties (ignoring blocks)	29	51.3700	.7890	5.7818
Error (intra-block)	163	14.8019	.2145	1.8391 ^(g)
Error (random block)	203	17.4009	.2324 ^(g)	1.9412
Total	239	24.3853	.3326	2.5188
Calculated F value		3.47**	3.40**	3.14**

(a, (b, (c) See page 155.

(e) Harvest stand

(f) General mean for 30 varieties in test

(g) Error term used

(h) Pounds per plot

(a) Recoverable Sugar

A technique, whereby thin juice purity could be determined from small samples, was first used in 1953, following methods developed in the G. W. Research Laboratory at Denver. Using the resultant purity figure, a calculated "Recoverable Sugar" is obtained. An example of the calculation is as follows:

Sugar in beets = 12.00%
 Standard total losses = 0.30%
 Sugar on beets at sugar end - 12.00 - 0.30 = 11.70%

Assume standard molasses purity = 62.5%
 100.0 - 62.5 = 37.5% Impurities on solids in molasses
 $\frac{62.5}{37.5} = 1.6667\%$ Sugar on impurities in molasses

Sugar sacked

85% purity thin juice = 15% impurities
 $\frac{15}{85} = 17.6471\%$ impurities on sugar

Sugar end = 11.70 x 17.6471% = 2.06471% on beets
 Molasses produced = 2.06471 x 1.66667 = 3.4413% on beets
 Sugar sacked = 12.00 - (0.30 + 3.4413) = 8.2587%

Recoverable sugar = $\frac{8.2587}{12.00} = 68.82\%$

(b) Approximation - Calculated as percentage of "difference required for significance for "gross" sugar on basis of relationship between general means for "Gross" and "Recoverable" sugar.

(c) Gross sugar calculated from the formula:

$$S \text{ lbs. sugar} = \text{Mean lbs. sugar} \sqrt{\left(\frac{S \text{ lbs. beets}}{\text{Mean lbs. beets}}\right)^2 + \left(\frac{S \% \text{ sugar}}{\text{Mean \% sugar}}\right)^2}$$

P A R T V

DEVELOPMENT AND EVALUATION
of
SUGARBEET BREEDING MATERIAL AND VARIETIES CARRYING
RESISTANCE TO LEAF SPOT AND CURLY TOP

Foundation Project 25

J. O. Gaskill
J. A. Elder

A. M. Murphy
G. E. Coe

Cooperation:

Amalgamated Sugar Company
American Crystal Sugar Company
Colorado Agricultural Experiment Station
Holly Sugar Corporation
National Sugar Manufacturing Company
Tribune Branch Station, Kansas
Agricultural Experiment Station
Southeastern Substation, New Mexico
Agricultural Experiment Station
Panhandle Experiment Station, Oklahoma
Agricultural Experiment Station

DEVELOPMENT AND EVALUATION OF SUGARBEET BREEDING
MATERIAL AND VARIETIES CARRYING RESISTANCE TO
LEAF SPOT AND CURLY TOP, 1964 1/

(A phase of Beet Sugar Development Foundation Project No. 25)

John O. Gaskill 2/

The commencement of full-scale commercial sugarbeet production in 1964 for the new Merrill E. Shoup Plant of the Holly Sugar Corporation, located at Hereford, Texas, brought with it an increased need for sugarbeet varieties possessing a high degree of resistance to both leaf spot and curly top, together with various other characters ordinarily considered desirable attributes of commercial sugarbeet varieties. Research conducted and coordinated at Fort Collins in 1964, pertaining to the development and evaluation of sugarbeet breeding material and varieties carrying combined resistance to leaf spot and curly top, represented a continuation of the major types of work described in the 1963 progress report on this subject (2) 3/. As in the past, the current report deals primarily with performance data of substance, and details regarding breeding work and results of preliminary evaluation of breeding lines have been largely omitted.

1/ This progress report pertains to breeding and evaluation work conducted at Fort Collins, Colorado, and to cooperative tests conducted elsewhere by various investigators, with results compiled at the Fort Collins station. The work at Fort Collins was performed by the Crops Research Division, A.R.S., U. S. Department of Agriculture, in cooperation with the Colorado Agricultural Experiment Station and the Beet Sugar Development Foundation, and was supported in part by funds contributed by the National Sugar Manufacturing Company. Assistance rendered by Joseph A. Elder and Luther W. Lawson, Agricultural Research Technicians, Crops Research Division, in conducting breeding, evaluation, and other work at Fort Collins, is acknowledged. Participation by other investigators in the research program covered by this report is acknowledged in the tables and accompanying discussion.

2/ Research Plant Pathologist, Crops Research Division, A.R.S., U. S. Department of Agriculture, Fort Collins, Colorado.

3/ Numbers in parentheses refer to Literature Cited.

Top-cross Tests

Two top-cross tests (Experiments 2A and 3A) were conducted at Fort Collins in 1964 as a part of a program of developing monogerm, type-0, leaf spot resistant inbred lines with satisfactory combining ability. As shown in Table 1, none of the type-0 lines involved in these two tests are considered resistant to curly top. However, since any such lines may have potential value for the production of LSR-CTR hybrids, information pertaining to their general combining ability has a rightful place in this report. The results of these two tests (especially Experiment 2A) also will be of interest to those concerned with the need for combined resistance to leaf spot and black root. Descriptions and results of the top-cross tests are presented in Tables 2(a), 2(b), 3(a), and 3(b).

The superior performance of 2 sets of hybrids involving FC 502, FC 502/2, FC 503, and FC 503/2, as shown in Table 2(b), is of special interest. Where the LSR-BRR variety, SP 5822-0, had served as the pollinator, each of the 4 hybrids significantly exceeded the most productive of the checks [SL (126 x 128) MS x SP 5822-0] both in sucrose percentage and in yield of gross sucrose. The average gross sucrose yield of the 4 hybrids exceeded that of the above check by 14.5%, a highly significant amount. Each of four corresponding hybrids, having US 401-pool (4n) as the ♂ parent, also exceeded the same check in sucrose percentage--3 of them significantly so--and their average gain over the check, in gross sucrose yield, was 16.2%. As indicated by the leaf spot grades reported in the table, injury caused by leaf spot was substantially lower among the 8 hybrids than in the check. However, it seems unlikely that the superior agronomic performance of the hybrids could have been due solely to their higher levels of leaf spot resistance. Evaluation of these or similar hybrids under non-leaf spot conditions would be desirable.

The agronomic performance of hybrids having the LSR-CTR variety, SP 6051-0, as the ♂ parent were rather disappointing [Table 3(b)], thus tending to agree with results reported for 1963 (2) for top-cross hybrids having the same ♂ parent. Of 2 hybrids having the CTR, bolting resistant variety, 663, as the ♂ parent, SP 631211H02 was rather outstanding in gross sucrose yield, though not significantly above SL (126 x 128) MS x SP 5822-0 [Table 3(b)]. The SP 6051-0 hybrids and the 663 hybrids were about equal to US 33 in curly top resistance, according to data obtained by Mr. A. M. Murphy at Thatcher, Utah, summarized in Table 3(b), and most of them were better than SL (126 x 128) MS x SP 5822-0 in leaf spot resistance.

Table 1 --Description of sugarbeet material involved in top-cross tests, Fort Collins, Colorado, 1964 (Exp. no. 2A and 3A).

Strain designation	Seed type	LSR	b/	CTR	b/	Description
<u>Type-0 lines:</u>						
FC 502 (a)	mm	+++	-	-	-	S ₁ inbred; rr; derived from the cross, V. F. Savitsky's # 715 mmQ x US 201 MM.
FC 502/2 (a)	mm	+++	-	-	-	S ₂ inbred; rr; a subline of FC 502.
FC 503 (b)	mm	++	-	-	-	Inbred; RR; derived (by selfing) from V. F. Savitsky's #716 (a mm inbred obtained from the cross, LSR MM x SLC 101 mm).
FC 503/2 (b)	mm	++	-	-	-	Inbred; RR; a subline of FC 503.
SP 581220s1	mm	++	-?	-?	-?	S ₁ inbred; rr; derived from cross, US 201 MM x type-0 mm.
SP 592000s1	mm	++	-?	-?	-?	Inbred; RR; derived (by selfing) from V. F. Savitsky's #6-2 (a mm line obtained from the cross, US 216 MM x SLC 101 mm).
SP 592060s1 (c)	mm	+	-?	-?	-?	S ₂ inbred; rr; derived from the cross, US 201 MM x type-0 mm.
SP 592084s1	mm	+++	-?	-?	-?	S ₂ inbred; R,r; derived from the cross, US 201 MM x SP 51101- mm.
SP 592087s1	mm	++	-?	-?	-?	S ₂ inbred; R,r; derived from the cross, US 201 MM x SP 51101- mm.
SP 592102s1 (c)	mm	++	-?	-?	-?	S ₂ inbred; rr; derived from the cross, US 201 MM x type-0 mm.
<u>Pollinators:</u>						
663	MM	-	++	++	++	Bolting resistant pollinator; developed by U.S.D.A., Salinas, California; furnished by J. S. McFarlane.
SP 5822-0	MM	+++	-	-	-	Black root resistant variety; developed by U.S.D.A., Beltsville, Md.
SP 591101-0	mm	++	-	-	-	Black root res. var. with equiv. of 1 gen. of sel. for res. to Botrytis (storage rot).
SP 6051-0	MM	+	++	++	++	Developed by U.S.D.A., Beltsville, Md., and N. M. Agr. Exp. Station; seed furnished by G. E. Coe.
US 401 4n pool	M	++	+	+	+	Pool of the following 4n lines, derived from US 401 2n by V. F. and Helen Savitsky: S-62-3, -8, -11, -14, and -27.
<u>Other material:</u>						
SL 122 MS x] SP 5460-0]	m	+	++	++	++	WC 2433; com'l. hybrid; seed furnished by F & M and West Coast Beet Seed Co.
SL 126 MS x] SP 5460-0]	m	+	++	++	++	WC 3335; com'l. hybrid; seed furnished by F & M and West Coast Beet Seed Co.
SL (126 x 128)MS] x SP 5822-0]	m	+	++	++	++	WC 3457; com'l. hybrid; seed furnished by F & M and West Coast Beet Seed Co.
SL (126 x 128)MS] x US 401 4n]	m	+	++	++	++	WC 3465; exp. hybrid; seed furnished by F & M and West Coast Beet Seed Co.

a/ Type-0 lines derived directly or indirectly from the progeny obtained by selfing the same F₂ root are designated by identical letters in parentheses.

b/ Rough classification with respect to leaf spot resistance (LSR) and curly top resistance (CTR), based on various sources of information and on personal opinion: +++ = high; ++ = fairly high; + = fair to medium; - = none; -? = probably none.

Table 2(a).--Description of top-cross test, LSR-BRR, monogerm hybrids,
Fort Collins, Colorado, 1964 (Exp. no. 2A).

Conducted by: J. A. Elder and J. O. Gaskill.

Location: Hospital Farm, Fort Collins, Colorado; field no. 1.

Cooperation: Colorado Agricultural Experiment Station, Beet Sugar Development Foundation, and National Sugar Manufacturing Company.

Dates of Planting and Harvest: April 24; October 19.

Experimental Design: Equalized random blocks; 32 x 8; plots 1 row x 24'; rows 20" apart; hand thinned to single-plant hills.

Determination of Root Yield: With a few minor exceptions, all roots in 21' of row in each plot were harvested. All harvested roots were hand topped, washed, and weighed.

Determination of Sucrose Percentage: All roots harvested for root-yield determination in each plot constituted one sample for sucrose analysis. Duplicate sucrose determinations were made for the composited pulp from each sample.

Stand: Very good (approximately 10" spacing).

Recent Cropping History: 1960, sugarbeet; 1961-1963, barley.

Chemicals Applied for 1964 Crop: Treble superphosphate (approximately 270 lbs. per acre) and ammonium nitrate (approximately 347 lbs. per acre) were applied before plowing in August, 1963. Shell DD (about 42 gal. per acre) was applied in August, 1963, for sugarbeet nematode control.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Western yellows and sugarbeet nematode, mild effects; other diseases and pests, negligible.

Soil and Seasonal Conditions: The 1964 crop season was warm and dry, on the whole. Adequate soil moisture was provided artificially, principally by furrow irrigation. Inoculation (July 9) and subsequent frequent sprinkling were used to promote the development of leaf spot (Cercospora beticola).

Reliability of Test: Good.

Remarks: Bolting was negligible.

Table 2(b).--Results of top-cross test, LSR-BRR, monogerm hybrids, Fort Collins, Colorado, 1964 (Exp. no. 2A). ^{a/}

Attri- bute	Perform- ance of	♀ (CMS of mm, LSR lines below	Equiv. stage	Pollinators (LSR-BRR)			Aver. of hbs.	Other material (LSR-BRR)		
				2n	4n	US 401 pool		SL 126 MS	SL(126 x	SL(126 x
				SP 5822-0	SP 591101-0	(Mono.)		x	128)MS x	128)MS x
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Roots per acre (tons)	Pol., etc.			13.56	13.13	13.96		14.04	14.22	12.85
	Hybrids	FC 502	B ₂	14.77	13.97	15.74	14.86			
	"	FC 502/2	B ₂	16.02	14.14	15.44	14.79			
	"	FC 503	B ₃	15.86	14.50	16.52	15.51			
	"	FC 503/2	B ₃ (+)	15.77	15.35	16.99	16.17			
	"	SP 592000s1	B ₁		14.49	14.64	14.57			
	"	SP 592087s1	B ₁	14.65	13.94	15.76	14.85			
	"	SP 592084s1	B ₂		11.48	14.99	13.24			
	"	SP 592102s1	B ₁		12.15	14.69	13.42			
	"	SP 592060s1	B ₁		13.06	14.67	13.87			
	"	SP 581220s1	B ₂	13.87	13.67	14.37	14.02			
	Average (hybrids, only)				13.68	15.38				
	LSD(.05) for 8-plot avers.			1.05	1.05					
	LSD(.05) for aver. of avers.				0.33	0.74				
Sucrose (%)	Pol., etc.			16.16	16.13	15.84		15.87	16.06	16.12
	Hybrids	FC 502	B ₂	16.85	16.81	16.46	16.64			
	"	FC 502/2	B ₂	17.11	17.00	16.41	16.71			
	"	FC 503	B ₃	16.46	16.60	16.43	16.52			
	"	FC 503/2	B ₃ (+)	16.58	16.75	16.36	16.56			
	"	SP 592000s1	B ₁		16.13	15.98	16.06			
	"	SP 592087s1	B ₁	16.03	16.07	15.99	16.03			
	"	SP 592084s1	B ₂		16.21	16.01	16.11			
	"	SP 592102s1	B ₁		16.33	15.91	16.12			
	"	SP 592060s1	B ₁		16.57	16.21	16.39			
	"	SP 581220s1	B ₂	16.28	16.10	16.09	16.10			
	Average (Hybrids, only)				16.46	16.19				
	LSD (.05) for 8-plot avers.			0.34	0.34	0.34				
	LSD (.05) for aver. of avers.				0.11	0.24				
Gross sucrose per acre (lbs.)	Pol., etc.			4383	4238	4421		4459	4567	4140
	Hybrids	FC 502	B ₂	4979	4695	5179	4937			
	"	FC 502/2	B ₂	5480	4809	5065	4937			
	"	FC 503	B ₃	5227	4817	5421	5119			
	"	FC 503/2	B ₃ (+)	5228	5143	5560	5352			
	"	SP 592000s1	B ₁		4676	4678	4677			
	"	SP 592087s1	B ₁	4699	4483	5038	4761			
	"	SP 592084s1	B ₂		3718	4798	4258			
	"	SP 592102s1	B ₁		3966	4678	4322			
	"	SP 592060s1	B ₁		4327	4756	4542			
	"	SP 581220s1	B ₂	4517	4401	4626	4514			
	Average (hybrids, only)				4504	4980				
	LSD(.05) for 8-plot avers.			355	355	355				
	LSD(.05) for aver. of avers.				112	251				
Leaf ^{b/} spot grade (8/26)	Pol., etc.			2.4	3.4	3.6		4.9	4.4	5.7
	Hybrids	FC 502	B ₂	2.4	2.9	3.0	3.0			
	"	FC 502/2	B ₂	1.8	2.7	3.1	2.9			
	"	FC 503	B ₃	2.4	2.8	3.3	3.1			
	"	FC 503/2	B ₃ (+)	1.8	2.3	3.1	2.7			
	"	SP 592000s1	B ₁		2.3	3.3	2.8			
	"	SP 592087s1	B ₁	1.3	2.9	2.8	2.9			
	"	SP 592084s1	B ₂		3.6	2.9	3.3			
	"	SP 592102s1	B ₁		2.7	3.3	3.0			
	"	SP 592060s1	B ₁		3.4	3.8	3.6			
	"	SP 581220s1	B ₂	2.9	4.3	4.2	4.3			
	Average (hybrids, only)				3.0	3.3				

^{a/} Basic results presented as 8-plot averages.

^{b/} Leaf spot grades (J. A. Elder): 0 = no leaf spot; 10 = complete defoliation.

Table 3(a).--Description of top-cross test, LSR-CTR monogerm hybrids,
Fort Collins, Colorado and Thatcher, Utah, 1964.

Fort Collins, Colorado, Exp. No. 3A

Conducted by: J. A. Elder and J. O. Gaskill.

Location: Hospital Farm, Fort Collins, Colorado; field no. 1.

Cooperation: Colorado Agricultural Experiment Station, Beet Sugar Development Foundation, and National Sugar Manufacturing Company.

Dates of Planting and Harvest: April 23-24; October 16.

Experimental Design: Equalized random blocks; 16 x 8; plots 1 row x 24'; rows 20" apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in 21' of row in each plot were hand topped, washed, and weighed.

Determination of Sucrose Percentage: All roots harvested for root-yield determination in each plot constituted one sample for sucrose analysis. Duplicate sucrose determinations were made for the composited pulp from each sample.

Stand and Bolter Counts: For stand, all hills were counted on September 21 in the area to be harvested in each plot. Bolter percentages were determined by counts (entire plots) in mid-season, and seed stalks were cut off at that time.

Recent Cropping History: 1960, sugarbeet; 1961-1963, barley.

Chemicals Applied for 1964 Crop: Treble superphosphate (approximately 270 lbs. per acre) and ammonium nitrate (approximately 347 lbs. per acre) were applied before plowing in August, 1963. Shell DD (about 42 gal. per acre) was applied in August, 1963, for sugarbeet nematode control.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Western yellows and sugarbeet nematode, mild effects; other diseases and pests, negligible.

Soil and Seasonal Conditions: The 1964 crop season was warm and dry, on the whole. Adequate soil moisture was provided artificially, principally by furrow irrigation. Inoculation (July 9) and subsequent frequent sprinkling were used to promote the development of leaf spot (Cercospora beticola).

Reliability of Test: Good.

Thatcher, Utah

An observational, curly top resistance, evaluation test was conducted by A. M. Murphy at Thatcher, Utah in 1964. The crop was planted on June 27, and moderate curly top exposure was promoted by artificial means. The plots were 1 row x 50' in size, and there were 2 replications.

Table 3(b).--Results of top-cross test, LSR-CTR, monogerm hybrids, Fort Collins, Colorado, and Thatcher, Utah, 1964 (Fort Collins Exp. no. 3A).

Description	Ft. Collins seed no.	Entry: no.	Gross sucrose: Roots	Acre yield	Fort Collins a/				Thatcher b/			
					Leaf spot	Vig.	d/	Stand	Bolt--	(hills : ers	C. T.	grade
					8/19: 8/26	7/31	per	100'	10/7			
				Lbs.	Tons			No.				
SP 6051-0 (LSR-CTR, MM)												
" " " "												
CMS (B2) of FC 502		SP 621228HO	284	13.45	---	---	---	---	---	---	---	4.0
CMS (B3+) of FC 503/2	MM	SP 631210HO	285	12.94	15.74	3.1	4.0	6.6	120	0.00	4.5	
CMS (B1) of SP 592000s1	"	" H01	286	14.89	16.53	2.6	3.3	6.5	120	0.00	5.5	
" " " "	"	" H04	287	14.56	16.65	2.4	3.3	7.5	122	0.00	5.5	
" " " "	"	" H05	288	15.42	15.28	2.7	3.5	6.9	118	0.00	5.5	
" " " "	"	" H06	289	14.70	16.24	2.5	3.1	6.9	122	0.85	5.5	
" " " "	"	" H07	290	13.87	16.35	2.4	2.8	6.8	120	0.00	5.5	
" " " "	"	" H08	291	13.77	16.46	2.4	3.0	7.4	122	0.45	5.5	
" " " "	"	" H09	292	13.53	16.84	2.7	3.3	7.6	119	0.00	5.0	
" " " "	"	" H010	293	13.31	16.03	3.4	3.6	6.3	120	0.00	5.0	
McFarlane 663 (CTR, bolt. res., MM)		SP 631211HO	294	14.05	14.88	5.5	6.6	5.8	122	0.00	5.0	
CMS (B2) of FC 502	MM	" H01	295	16.42	16.03	3.7	4.8	6.4	124	0.00	5.5	
CMS (B3) of FC 503/2	"	" H02	296	12.40	15.58	3.3	3.9	7.3	122	0.00	5.5	
SL 122 MS x SP 5460-0		Acc. 2528	297	3794	15.31	5.6	6.2	6.3	122	0.41		
SL 126 MS x SP 5460-0		" 2585	298	4369	15.75	4.2	4.8	7.1	122	0.00		
SL (126 x 128) MS x SP 5822-0		" 2588	299	4802	16.06	3.3	4.1	7.3	120	0.00		
SP 5822-0 (LSR-BRR, MM)		" 2591	299	4513	16.01	1.7	2.0	6.8	119	0.00		
General mean			4520.72	14.1353	15.9826							
SE of entry mean			121.09	0.3699	0.1525							
SE of entry mean as % of gen. mean			2.68	2.62	0.95							
LSD (.05)			340	1.04	0.43							

a/ 8-plot averages.

b/ 2-plot averages. Basis of curly top grades (A. M. Murphy): 0 = healthy; 9 = death due to curly top. Curly top grades for check varieties: US 33, 5.5; SP 5481-0, 6.5.

c/ Basis of leaf spot grades (J. A. Elder): 0 = no leaf spot; 10 = complete defoliation.

d/ Foliage vigor: larger number = greater vigor.

Development of Monogerm, Type-0, LSR-CTR Inbred Lines

Use of the backcross method to produce basic material (SP 611100-0 and SP 611101-0), from which monogerm, type-0, LSR-CTR, inbred lines could be derived, was discussed on page 187 of the 1963 progress report (2). Also, on page 188 of that report, results of preliminary leaf spot and curly top resistance evaluation tests of some of the resultant type-0 and near-type-0 lines were presented.

This type of work was continued in 1964, using the same or similar basic material, with the assistance of Dr. C. L. Schneider, Plant Pathologist in this Division, who performed the curly top resistance evaluation work in the greenhouse at Logan, Utah. This greenhouse method, utilizing small numbers of young plants, is highly advantageous in that it permits an immediate appraisal of resistance of new, type-0, S₁ lines. Most of the seed lots shared with Dr. Schneider were S₁ lots produced by bagging. All were considered acceptable in pollen production. As shown in Table 4, several of these lines, having a perfect "0-rating" (100/0) or nearly so, were approximately equal to or better than SP 5481-0 and US 41 in leaf spot resistance and curly top resistance, respectively.

Table 4 ---Evaluation of leaf spot and curly top resistance of new, monogerm, type-0 and near-type-0 inbred lines, Fort Collins, Colorado, and Logan, Utah, 1964.

Immediate parent or description	Strain no.	Pol. rating	a/0-ing	b/0-ing	LSR evaluation and vigor	c/	CTR evaluation	d/	e/	f/	g/	h/
					No. : LS grade	Vig.	No. : CT	infect.	sever-			
					Entry: of		Code	plants	ity			
					no. : plots	7/30:8/18:8/25: 7/30	no. : plants					
<u>Type-0 Lines (Exp. 6A)</u>												
SP 611100-0	SP 632016s1	5	100/0	401	2	1.5 4.0 5.5 5.5	64-21	11	108			
SP 611101-0	SP 632028s1	6	100/0	407	1	1.0 2.0 2.0 5.0	64-22	14	102			
do.	SP 632029s1	6	91/0	409	1	2.0 5.0 5.0 6.0	64-23	10	87			
do.	SP 632090s1c1	5	96/0	415	1	2.0 3.0 3.0 6.0	64-24	14	102			
do.	SP 632106s1c1	5	100/0	422	2	2.0 3.8 3.5 6.0	64-25	14	100			
SP 621103-0	SP 632019s1	5	100/0	425	2	2.3 5.5 5.5 5.0	64-26	14	92			
do.	SP 632025s1	6	100/0	427	2	2.0 3.0 3.3 5.0	64-27	9	100			
do.	SP 632033s1	4	100/0	429	1	2.0 5.0 4.0 5.0	64-28	10	94			
do.	SP 632034s1	6	100/0	431	1	2.0 4.0 3.0 6.0	64-29	6	91			
do.	SP 632067s1	6	95/0	434	2	1.5 2.5 2.5 6.0	64-30	4	127			
<u>Checks for LSR Evaluation (Exp. 6A)</u>												
SP 5481-0	Acc. 2483			481	8	1.6 2.6 3.0 6.1						
Syn. Check	Acc. 2269			480	6	2.9 5.7 6.4 6.0						
<u>Type-0 Line (Exp. 4A)</u>												
SP 612070s1c1	SP 631170HO	5	92/0	502	3	0.4 1.0 1.3 5.0	64-31	8	105			
<u>Checks for LSR Evaluation (Exp. 4A)</u>												
SP 5481-0	Acc. 2483			524	3	2.3 3.8 4.7 6.7						
Syn. Check	Acc. 2269			525	3	4.0 6.0 7.0 5.7						
<u>Checks for all CTR Evaluations (Logan)</u>												
US 41								24	100			
US 22/4								22	87			
SP 6051-0	SP 631210HO						64-34	4	105			
SP 5481-0	Acc. 2483						64-33	14	138			

a/ Quantity of pollen shed by the individual plant that was selfed to produce the indicated "s1" or "c1" strain no. Basis of grades: 1-7 in ascending order of abundance (ordinary, open-pollinated, commercial variety usually rated 6 or 7).

b/ Pertains to the indexing population (at least 20 plants); left number is percentage classed as male sterile; right number is percentage classed as male fertile; percentage unaccounted for, if any, represents intermediate types.

c/ Field plots on Hospital Farm, Fort Collins, Colorado; inoculation and frequent sprinkling used to promote leaf spot development. Plots in Exp. 6A were 1 row x 24', flanked uniformly by a leaf spot susceptible strain; plots in Exp. 4A were 4 rows x 24'.

d/ Curly top resistance evaluation by C. L. Schneider, Logan, Utah, using greenhouse seedling technique with Schneider's culture A1A of the curly top virus (about equal to strain 11 in virulence) and 1 caged leafhopper per plant.

e/ Leaf spot grades (J. A. Elder): 0 = no leaf spot; 10 = complete defoliation.

f/ Foliage vigor (J. A. Elder): Larger no. = greater vigor.

g/ Curly top severity (C. L. Schneider). The plants were classified individually on a scale of 0 - 9 (0 = no symptoms, 9 = dead). Plants without curly top symptoms were disregarded. Results for plants with curly top symptoms were averaged by strains, and the averages were converted to percent of US 41. Thus, values less than 100 (shown above) indicate less curly top injury than in US 41, and values greater than 100 indicate more curly top injury than in US 41.

Cooperative Evaluation Tests of LSR-CTR Varieties

Seed supplies of the 7 varieties listed in Table 5 were assembled at Ft. Collins and distributed to cooperators for evaluation. Cooperators usually added 1 or 2 varieties to serve as "local checks". The results were compiled at Ft. Collins and are presented in the following pages. Location, type of test, and certain other information regarding these trials are as follows:

<u>State</u>	<u>Locality</u>	<u>Type</u> ^{a/}	<u>Agency conducting test</u>	<u>Table</u>
Calif.	Hamilton City	A	Holly Sugar Corp.	14(a), 14(b)
"	Tracy <u>b/</u>	A	" " "	
Colo.	Ft. Collins	A	U. S. Dept. of Agr.	7(a), 7(b)
"	Holly	A	Amer. Crystal Sug. Co.	10(a), 10(b)
"	Rocky Ford	A	" " " "	9(a), 9(b)
"	Sugar City	A	National Sug. Mfg. Co.	8(a), 8(b)
Iowa	Mason City	A	Amer. Crystal Sug. Co.	13(a), 13(b)
"	Tekomah	A	" " " "	12(a), 12(b)
Kan.	Garden City	A	" " " "	10(a), 10(b)
"	Johnson	A	" " " "	10(a), 10(b)
"	Tribune	A	National Sug. Mfg. Co. and Kan. Agr. Exp. Station	11(a), 11(b)
Md.	Beltsville	A	U. S. Dept of Agr.	19
Neb.	Kearney	A	Amer. Crystal Sug. Co.	12(a), 12(b)
"	Shelton	A	" " " "	12(a), 12(b)
N. M.	Artesia	A	N. M. Agr. Exp. Station	18(a), 18(b)
Okla.	Goodwell	A	Okla. Agr. Exp. Station	16(a), 16(b)
Oreg.	Nyssa	A	Amalgamated Sug. Co.	15(a), 15(b)
Tex.	Hereford	A	Holly Sugar Corp.	17(a), 17(b)
Utah	Logan	O	U. S. Dept. of Agr.	21
"	Thatcher	O	" " " " "	20

a/ Type of test: A = agronomic; O = observational.

b/ To be harvested late.

Results for the individual tests are presented in the tables listed above. A general summary of agronomic data is given in Table 6. A striking varietal contrast under severe curly top exposure is shown in Figure 1. In cooperative tests conducted in 1962 and 1963, the monogerm hybrid, SL 122 MS x SP 5460-0, was considered as a standard. As previously reported (1, 2), another monogerm hybrid, SL 126 MS x SP 5460-0, exceeded that standard by an average of 11 percent in gross sucrose yield in the cooperative tests of 1962 and 1963. For the 1964 tests, SL 126 MS x SP 5460-0 was used as the standard.

Except for the Ft. Collins and Beltsville tests, leaf spot was not an important factor in the 1964 cooperative tests. The unusually low level of leaf spot exposure is attributed largely to weather conditions in 1964. However, it should be recognized that leaf spot was partially controlled by spraying in some of the locations in Nebraska and Iowa. Curly top exposure was severe at Goodwell, Okla., Hereford, Texas, and



Figure 1.--Comparison of sugarbeet varieties under severe curly top exposure, Artesia, New Mexico, 9/25/64; plots 4 rows (i.e., 2 beds) wide and 22 ft. long. Left, (SL 126 x 128 MS) X SP 5822-0; right, SP 5822-0. (Ft. Collins photo no. 172-28).

Artesia, New Mexico. Under such a wide range of disease conditions and other environmental factors, substantial variety x location interaction was to be expected and may be readily observed in Table 6. Consequently, the general averages shown in that table for such "varieties" (i.e. entries) as no. 6 (susceptible to curly top) and no. 7 (susceptible to leaf spot) are of little value. However, since each of the varieties, 1 through 5, is somewhat resistant to both leaf spot and curly top, certain comparisons among the general averages for those varieties are of interest.

Variety no. 2 was equal to the standard (variety no. 1--i.e. SL 126 MS x SP 5460-0) in sucrose percentage and was 98 percent of standard in root and gross sucrose yield. The over-all performance of varieties 3, 4, and 5 may be summarized by stating that, in percent of standard, those varieties ranged from 101 to 102 in sucrose percentage, 101 to 103 in root yield, and 102 to 104 in gross sucrose yield.

A comparison of SP 5460-0 and SP 5822-0, for use as pollinators, may be of interest. The former served as the σ parent of varieties 1 and 2, and the latter was the σ parent of varieties 3 and 4. Otherwise, the parentage of varieties 1 and 3 was identical, and that of varieties 2 and 4 was identical. In the general averages for gross sucrose yield (Table 6) it may be observed that each of the varieties having SP 5822-0 as the σ parent (i.e. varieties 3 and 4) was 4 percent higher than the corresponding variety having SP 5460-0 as the σ parent. These results indicate a modest but probably "real" superiority for SP 5822-0 as a pollinator of the females, SL 126 MS and SL (126 x 128) MS. In comparing these 2 females, the results in Table 6 are slightly in favor of the former.

Although the LSR-CTR varieties, 3, 4, and 5, performed acceptably under leaf spot exposure and also under curly top conditions (Table 6), it should be noted (Tables 20, 21, etc.) that the curly top resistance of those varieties is substantially lower than that of the better curly top resistant checks. Likewise, it should be noted [Tables 7(b), 19, etc.], that the leaf spot resistance of varieties 3, 4, and 5 is much lower than that of the leaf spot resistant check, variety no. 6. These results agree with those of other experiments in indicating that, for the production of hybrid varieties with high levels of resistance to both leaf spot and curly top, the parental lines must have high resistance to both diseases.

Literature Cited

- (1) Gaskill, John O., et al. Development and evaluation of sugarbeet breeding material and varieties carrying resistance to leaf spot and curly top, 1962. Sugarbeet Research, 1962 Report (CR-4-63, Crops Research Division, A.R.S., U.S.D.A.): 139-160.
- (2) Same as above, but for 1963. Sugarbeet Research, 1963 Report (CR-4-64): 179-210.

Table 5.--Description of material in cooperative agronomic evaluation tests of LSR-CTR varieties, 1964.

Entry no.	Ft. Collins seed no.	Description and supplier ^{a/}
1	Acc. 2585	SL 126 MS x SP 5460-0; monogerm; LSR-CTR, Farmers & Manufacturers Beet Sugar Assoc. and West Coast Beet Seed Co. (WC lot 3335).
2	Acc. 2586	SL (126 x 128) MS x SP 5460-0; monogerm; LSR-CTR; F. & M. and West Coast Beet Seed Co. (WC lot 3452).
3	Acc. 2587	SL 126 MS x SP 5822-0; monogerm; LSR-CTR; F. & M. and West Coast Beet Seed Co. (WC lot 3462).
4	Acc. 2588	SL (126 x 128) MS x SP 5822-0; monogerm; LSR-CTR; F. & M. and West Coast Beet Seed Co. (WC lot 3457).
5	Acc. 2589	SL (129 x 133) MS x SP 5822-0; monogerm; LSR-CTR; F. & M. and West Coast Beet Seed Co. (WC lot 3455).
6	Acc. 2591	SP 5822-0; a multigerm, U.S.D.A. variety, resistant to leaf spot and black root, developed for use in eastern sugarbeet areas; included in these cooperative tests as an LSR check; seed furnished by F. & M. and West Coast Beet Seed Co. (WC lot 3378).
7	Acc. 2584	US H2; a multigerm, U.S.D.A., bolting resistant, curly top resistant hybrid developed for use in California; included in these tests as a CTR check; seed furnished by J. S. McFarlane, U.S.D.A., Salinas, California.
8		Local check; furnished by cooperator.
9		" " " " " (occasional).

^{a/} Parental material used to produce the LSR-CTR hybrids listed in this table may be described as follows: SL-- monogerm, curly top resistant, susceptible to leaf spot, developed by the Salt Lake City, Utah, Station, U.S.D.A.; SP-- multigerm, resistant to leaf spot and black root, susceptible to curly top, developed by the Beltsville, Maryland, Station, U.S.D.A.

Tabla 6.--General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1964; as percent of standard (SL 126 MS x SP 5460-0)

Location	Dis. ^{a/}	Entry no.										ab/	9b/	LSR
		1	2	3	4	5	6	7	8	9	10			(.05)
<u>Gross Sucrose Yield</u>														
(1) Ft. Collins, Colo.	LS (S)	100	91	105	103	106	97	91	108	--	8			
(2) Sugar City, Colo.		100	104	103	108	105	96	89	94	--	11			
(3) Rocky Ford, Colo.	[LS (S1)]	100	89	87	85	89	72	66	81	76	16			
(4) Holly, Colo., and Johnson and Garden City, Kan.	[CT (S1)]	100	91	108	104	97	92	102	101	--	--			
(5) Tribune, Kansas	[CT (S1)]	100	102	106	108	107	107	111	102	--	11			
(6) Kearney and Shelton, Neb., and Tekomuh, Iowa	LS (M)	100	92	100	105	99	99	91	93	--	--			
(7) Mason City, Iowa		100	102	109	98	105	92	95	100	100	13			
(8) Hamilton City, Calif.		100	103	110	108	110	66	148	176	164	14			
(9) Nyssa, Oregon		100	97	104	98	107	85	110	101	110	6			
(10) Goodwell, Okla.	CT (S)	100	100	94	99	99	41	94	106	80	--			
(11) Hereford, Texas	CT (S)	100	105	106	101	103	64	104	99	92	8			
(12) Artesia, N. Mex.	[CT (S)]	100	98	110	107	122	22	122	82	107	--			
(13) Beltsville, Md.	[LS (S1)]	100	101	106	107	94	119	67	101	--	13			
		[BR?]												
General average		100	98	104	102	103	81	99						
<u>Root Yield</u>														
(1) Ft. Collins, Colo.	LS (S)	100	92	103	100	103	95	96	106	--	6			
(2) Sugar City, Colo.		100	102	103	106	102	96	93	92	--	11			
(3) Rocky Ford, Colo.	[LS (S1)]	100	91	89	87	87	72	68	81	74	15			
(4) Holly, Colo., and Johnson and Garden City, Kan.	[CT (S1)]	100	91	106	103	94	92	106	96	--	--			
(5) Tribune, Kan.	[CT (S1)]	100	104	109	110	106	106	115	102	--	10			
(6) Kearney and Shelton, Neb., and Tekomah, Iowa	LS (M)	100	94	101	105	98	100	95	95	--	--			
(7) Mason City, Iowa		100	103	108	97	106	93	97	102	103	--			
(8) Hamilton City, Calif.		100	102	106	103	105	62	140	155	151	10			
(9) Nyssa, Oreg.		100	95	101	96	103	87	107	96	106	5			
(10) Goodwell, Okla.	CT (S)	100	98	90	96	94	39	96	104	79	--			
(11) Hereford, Tex.	CT (S)	100	105	106	102	103	62	102	101	90	7			
(12) Artesia, N. Mex.	[CT (S)]	100	96	105	102	119	22	127	94	118	16			
(13) Beltsville, Md.	[LS (S1)]	100	104	108	104	93	112	78	105	--	11			
		[BR?]												
General average		100	98	103	101	101	80	102						
<u>Percent Sucrose</u>														
(1) Ft. Collins, Colo.	LS (S)	100	98	102	103	103	102	95	102	--	3			
(2) Sugar City, Colo.		100	102	100	102	103	101	96	102	--	4			
(3) Rocky Ford, Colo.	[LS (S1)]	100	98	98	97	102	100	97	100	103	--			
(4) Holly, Colo., and Johnson and Garden City, Kan.	[CT (S1)]	100	100	102	101	103	101	96	106	--	8			
(5) Tribune, Kan.	[CT (S1)]	100	98	98	99	100	100	97	101	--	3			
(6) Kearney and Shelton, Neb., and Tekomah, Iowa	LS (M)	100	98	99	100	101	99	96	97	--	5			
(7) Mason City, Iowa		100	99	100	101	99	99	97	98	97	--			
(8) Hamilton City, Calif.		100	101	104	105	105	106	106	114	109	--			
(9) Nyssa, Oreg.		100	102	103	102	104	98	103	105	104	4			
(10) Goodwell, Okla.	CT (S)	100	104	104	102	104	107	97	102	102	--			
(11) Hereford, Tex.	CT (S)	100	101	100	99	100	103	102	98	103	--			
(12) Artesia, N. Mex.	[CT (S)]	100	101	105	105	102	103	96	87	91	--			
(13) Beltsville, Md.	[LS (S1)]	100	97	99	103	101	106	86	96	--	7			
		[BR?]												
General average		100	100	101	101	102	102	97						

a/ Disease exposure considered sufficient to affect results appreciably: BR = black root; CT = curly top; LS = leaf spot; (S) = severe; (M) = medium; (S1) = slight or mild exposure.

b/ Local checks used at the respective locations: (1) GW 674-56C; (2) SL 122 MS x SP 5460-0; (3) entry 8, Am 2 Mono, and entry 9, Am 2 Multi; (4) Am 2 Mono; (5) SL 122 MS x SP 5460-0; (6) Am #3S Mono; (7) Am #3S Mono, and Am #3S Multi; (8) HH9 and NBHHL; (9) US 35/2 and S32 DR 10; (10) HH 10 and HH 12; (11) HH 10 and HH 12; (12) SP 6051-0 and HH 10; (13) SP 6351-0.

Table 7(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Fort Collins, Colorado, 1964 (Exp. no. 1A).

Conducted by: J. A. Elder and J. O. Gaskill.

Location: Hospital Farm, Fort Collins, Colorado; field no. 1.

Cooperation: Colorado Agricultural Experiment Station, Beet Sugar Development Foundation, and National Sugar Manufacturing Company.

Dates of Planting and Harvest: April 23; October 16.

Experimental Design: Latin Square, 8 x 8; plots 2 rows x 24'; rows 20" apart; hand thinned to single-plant hills.

Determination of Root Yield: All roots in a 21' section of each plot row were hand topped, washed, and weighed.

Determination of Sucrose Percentage: All roots harvested for root-yield determination in each plot were divided into 2 samples for sucrose analyses. Duplicate sucrose determinations were made for the composited pulp from each sample.

Stand and Bolter Counts: For stand, all hills were counted on September 21 in the area to be harvested in each plot. Bolter percentages were determined by counts (entire plots) in mid-season, and seed stalks were cut off at that time.

Recent Cropping History: 1960, sugarbeet; 1961-1963, barley.

Chemicals Applied for 1964 Crop: Treble superphosphate (approximately 270 lbs. per acre) and ammonium nitrate (approximately 347 lbs. per acre) were applied before plowing in August, 1963. Shell DD (about 42 gal. per acre) was applied in August, 1963, for sugarbeet nematode control.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Western yellows and sugarbeet nematode, mild effects; other diseases and pests, negligible.

Soil and Seasonal Conditions: The 1964 crop season was warm and dry, on the whole. Adequate soil moisture was provided artificially, principally by furrow irrigation. Inoculation (July 9) and subsequent frequent sprinkling were used to promote the development of leaf spot (Cercospora beticola).

Reliability of Test: Good.

Table 7(b) .--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Fort Collins, Colorado, 1964 (Exp. 1A, 8-plot averages).

Description	Ft. Col.:	seed	Entry:	no.	: no.	: sucrose:	Roots :	Lbs.	Tons	%	No.	%	Stand :	b/:	Vigor: (Hills	:Bolters
SL 126 MS x SP 5460-0	Acc.	2585	1	4516	14.43	15.58	2.3	4.0	4.8	7.3	116	0.24				
SL(126 x 128)MS x SP 5460-0	Acc.	2586	2	4102	13.34	15.27	2.4	4.3	5.3	7.3	116	0.23				
SL 126 MS x SP 5822-0	Acc.	2587	3	4739	14.86	15.91	2.1	3.6	4.2	7.4	118	0.00				
SL(126 x 128)MS x SP 5822-0	Acc.	2588	4	4648	14.50	15.99	2.5	4.1	4.7	7.1	115	0.23				
SL(129 x 133)MS x SP 5822-0	Acc.	2589	5	4783	14.92	16.00	2.1	3.6	4.3	6.9	116	0.00				
SP 5822-0; LSR check	Acc.	2591	6	4375	13.76	15.89	1.3	2.1	2.4	7.1	114	0.48				
US H2; CTR check	Acc.	2584	7	4125	13.89	14.80	3.2	6.0	6.9	5.6	116	0.00				
GW 674-56C; Local check	Acc.	2168	8	4870	15.27	15.96	2.2	3.4	4.6	7.3	117	0.00				
General mean				4519.80	14.3713	15.6744										
S. E. of var. mean				131.68	0.3264	0.1847										
S. E. of var. mean as % of Gen. mean				2.91	2.27	1.18										
L.S.D. (5% point)				376	0.93	0.53										

Variance Table

Source of Variation	D/F	Mean Square (variance)			
		Gross	sucrose	Roots	Sucrose %:
Rows	7	2,015,303.4	13,8683	2,4488	
Columns	7	83,212.0	0.5242	0.3005	
Varieties	7	694,867.0	3.4659	1.5236	
Error (remainder)	42	138,707.9	0.8524	0.2729	
Total	63				
Calculated F value		5.01**	4.07**	5.58**	

a/ Leaf spot: 0 = no leaf spot; 10 = complete defoliation.
b/ Foliage vigor: Larger no. = greater vigor.

Table 8(a) .--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Sugar City, Colorado, 1964.

Conducted by: Loyd H. Dillon, National Sugar Manufacturing Company.

Location: Factory grounds, Sugar City, Colorado.

Dates of Planting and Harvest: April 23-24; October 16-17.

Experimental Design: Latin Square, 8 x 8; plots 6 rows x 30'; rows 22" apart; hand thinned.

Determination of Root Yield: Two rows x 28' in each plot.

Determination of Sucrose Percentage: All roots harvested for yield determination were analyzed for sucrose content, usually as 3 or 4 samples per plot.

Stand Counts: Harvested roots.

Recent Cropping History: Alfalfa, 1961-1963.

Chemicals Applied for Sugarbeet Crop: 200# of 18-46-0 fertilizer; 4 1/2 pints of Tillam herbicide broadcast and disked in.

Leaf Spot Exposure: Negligible.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: The season was warm and dry; irrigation was adequate.

Reliability of Test: Very good.

Table 8(b) --Results of cooperative agronomic evaluation test of LSR-CTR varieties, Sugar City, Colorado, 1964 (8-plot averages).

Description	Ft. Collins:		Acre yield		Stand	
	seed	Entry	Gross	Sucrose	(beets per	100')
	no.	no.	sucrose	Roots	100'	
			Lbs.	Tons	%	No.
SL 126 MS x SP 5460-0	Acc. 2585	1	6590	19.18	17.15	122
SL (126 x 128) MS x SP 5460-0	Acc. 2586	2	6833	19.50	17.56	130
SL 126 MS x SP 5822-0	Acc. 2587	3	6805	19.79	17.18	132
SL (126 x 128) MS x SP 5822-0	Acc. 2588	4	7101	20.39	17.43	131
SL (129 x 133) MS x SP 5822-0	Acc. 2589	5	6897	19.52	17.67	131
SP 5822-0; LSR check	Acc. 2591	6	6329	18.40	17.24	134
US H2; CTR check	Acc. 2584	7	5870	17.87	16.47	111
SL 122 MS x SP 5460-0; local check		8	6170	17.66	17.46	135

General mean	6574.27	19.0397	17.2695
S. E. of var. mean	256.74	0.7347	0.2542
S. E. of var. mean as % of gen. mean	3.91	3.86	1.47
L.S.D. (.05)	733	2.10	0.73

Variance Table

Source of Variation	D/F	Mean square (variance)	
		Gross sucrose	Sucrose %
Rows	7	1,423,855.1	11.0063
Columns	7	583,567.1	2.8840
Varieties	7	1,395,633.9	7.4537
Error (remainder)	42	527,303.0	4.3175
Total	63		
Calculated F value		2.65*	1.73
			2.14

Table 9(a) .--Description of cooperative agronomic evaluation test of
LSR-CTR varieties, Rocky Ford, Colorado, 1964.

Conducted By: American Crystal Sugar Company.

Location: Rocky Ford, Colorado.

Dates of Planting and Harvest: April 13; October 3.

Experimental Design: Triple Lattice, repeated 3 times, 9 replications;
plots 1 row x 35'; rows 22" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Approximately one-half of the
beets per plot were bulked as one sample.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Very light.

Curly Top Exposure: Very light.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Season was extremely dry; stand
damaged some by winds after thinning.

Reliability of Test: Fair to Good.

Table 9(b).--Results of cooperative agronomic evaluation test of LSK-CJR varieties, Rocky Ford, Colorado, 1964 (9-plot averages).

Description	: Ft. Col. : : seed : : no. :	: Entry : : no. :	: Acre Yield :		: Stand : : (Roots : : per 35') :
			Lbs.	Tons	
SL 126 MS x SP 5460-0	Acc. 2585	1	7054	22.31	15.81 37.6
SL (126 x 128) MS x SP 5460-0	Acc. 2586	2	6289	20.26	15.52 27.8
SL 126 MS x SP 5822-0	Acc. 2587	3	6137	19.76	15.53 30.4
SL (126 x 128) MS x SP 5822-0	Acc. 2588	4	5980	19.44	15.38 31.7
SL (129 x 133) MS x SP 5822-0	Acc. 2589	5	6247	19.46	16.05 29.9
SP 5822-0	Acc. 2591	6	5062	16.02	15.80 28.6
US H2	Acc. 2584	7	4651	15.16	15.34 26.0
59-415-0 & 58-412-0 (Am #2 Mono) local ck		8	5686	17.97	15.82 32.0
54-406-0 (Am #2 Multi) local ck		9	5385	16.53	16.29 31.8
General Mean			5836	18.55	15.73 30.6
L.S.D. (5% Point)			1094	3.35	--
F. Value			--	3.77**	NS
C. V. %			19.84	19.19	5.05 23.29

Variance Table a/

Source of Variation	: D.F. :	: Roots (lbs.) :	Mean Square (variance)		: No. Roots (35') :
			Sucrose %	Sucrose %	
Replications	8	239.9312	1.1800		20.375
Component (a)	12		0.8150		48.083
Component (b)	6		0.6350		63.166
Blocks	18		0.7550		53.111
Varieties	8	414.9150	0.8925		97.500
Error (Intra-Block)	46	111.2371	0.5934		49.956
Error (Random Block)	64	110.1001			
Total	80	153.5647	0.7184		52.463

a/ For Gross Sucrose: SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$$

Table 10(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Holly, Colorado, and Johnson and Garden City, Kansas, 1964.

Conducted by: American Crystal Sugar Company.

Location: Holly, Colorado, Johnson, Kansas, and Garden City, Kansas.

Dates of Planting and Harvest: April 14-20; October 21, approximately.

Experimental Design: Randomized blocks; 8 entries; 3 replications at each of the 3 locations; plots 1 row x 35'; rows 22" - 24" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Beets from the complete plot were divided into 2 equal samples for sucrose determinations.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Moderate at Johnson, Kansas; light at the other 2 locations.

Curly Top Exposure: Moderate to heavy at Johnson, Kansas; light at the other 2 locations.

Other Diseases and Pests: Some yellow vein.

Soil and Seasonal Conditions: Soil type, sandy loam at Holly and heavy at Garden City. The season was extremely dry. The plots at Johnson became very weedy.

Reliability of Test: Satisfactory on the whole, though average stands were rather poor in entries 2 and 5 in the Johnson location.

Table 11(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Tribune, Kansas, 1964.

Conducted by: Roy E. Gwin, Jr., and Henry Wolfe.

Location: Tribune Branch Station, Kansas Agricultural Experiment Station, Tribune, Kansas.

Cooperation: Kansas Agricultural Experiment Station and the National Sugar Manufacturing Company.

Dates of Planting and Harvest: April 21; October 15.

Experimental Design: Latin Square, 8 x 8; plots 6 rows x 30'; rows 22" apart; hand thinned.

Determination of Root Yield: 50' of row in each plot.

Determination of Sucrose Percentage: All roots harvested for yield determination were analysed for sucrose content, usually as 3 samples per plot.

Stand Counts: Harvested roots.

Previous Crop: Field beans.

Fertilizer Applied for Sugarbeet Crop: 100# of nitrogen.

Leaf Spot Exposure: Negligible.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: Some wind and hail damage. Ten irrigations were applied. Two of these (the 2d and 3d) were used to control blowing soil.

Reliability of Test: Satisfactory.

Table 11(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Tribune, Kansas, 1964 (8-plot averages).

Description	Ft. Collins:		Acre yield		Stand	
	seed	Entry	Gross	Sucrose	(beets per	
	no.	no.	sucrose	Roots	100')	
			Lbs.	Tons	%	No.
SL 126 MS x SP 5460-0	Acc. 2585	1	6703	22.08	15.15	92
SL (126 x 128) MS x SP 5460-0	Acc. 2586	2	6836	22.97	14.86	97
SL 126 MS x SP 5822-0	Acc. 2587	3	7132	23.96	14.86	92
SL (126 x 128) MS x SP 5822-0	Acc. 2588	4	7266	24.26	14.95	85
SL (129 x 133) MS x SP 5822-0	Acc. 2589	5	7139	23.47	15.17	83
SP 5822-0; LSR check	Acc. 2591	6	7144	23.51	15.14	92
US H2; CTR Check	Acc. 2584	7	7441	25.40	14.62	90
SL 122 MS x SP 5460-0; local check		8	6864	22.47	15.27	100
General mean			7065.64	23.5134	15.0022	
S. E. of var. mean			255.32	0.7735	0.1771	
S. E. of var. mean as % of gen. mean			3.61	3.29	1.18	
L.S.D. (.05)			729	2.21	0.51	

Variance Table					
Source of Variation	D/F	Gross sucrose	Mean square (variance)	Roots	Sucrose %
Rows	7	3,045,503.0	14.2020	2.5466	
Columns	7	1,477,679.3	12.0527	0.8519	
Varieties	7	482,387.3	8.8609	0.3756	
Error (remainder)	42	521,514.4	4.7860	0.2509	
Total	53				
Calculated F value	0.92	1.85			1.50

Table 12(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Kearney and Shelton, Nebraska, and Tekomah, Iowa, 1964.

Conducted by: American Crystal Sugar Company.

Location: Kearney, Nebraska, Shelton, Nebraska, and Tekomah, Iowa.

Dates of Planting and Harvest: April 16; October 7-12.

Experimental Design: Randomized blocks; 8 entries; 3 replications at each of the 3 locations; plots 1 row x 35'; rows 22" - 24" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Beets from complete plot were divided into 2 equal samples for sucrose determinations.

Stand Counts: Harvested beets were counted when weighed.

Leaf Spot Exposure: Medium-severe at Kearney and Shelton; trace at Tekomah (4 applications of tri-basic copper spray).

Curly Top Exposure: None.

Other Diseases and Pests: Savoy averaged 4.8%, 10.4%, and trace at Kearney, Shelton, and Tekomah, respectively. Yellow vein averaged 3.7% at Kearney and 4.2% at Shelton. Savoy and yellow vein percentages, shown in table of results, represent Kearney, Shelton, and Overton, Nebraska, and disregard Tekomah, Iowa (Overton plots not harvested for yield data).

Soil and Seasonal Conditions: Light to medium heavy soil at Kearney and Shelton, Nebraska; silt loam (Missouri River bottom land) at Tekomah, Iowa. Fall weather was classed as "good"--i.e. cool nights and warm days with sunshine.

Reliability of Test: Satisfactory, on the whole. Stand deficiencies at Tekomah, Iowa, may have handicapped some varieties to a moderate extent at that location (e.g. entries 2 and 7, and possibly 4 and 5).

Table 12(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Kearney and Shelton, Nebraska, and Tekomah, Iowa, 1964 (9-plot averages except as indicated).

Description	Ft. Col.:		Acre Yield		L.S. a/Stand		b/	
	seed	Entry: Gross	no.	no. : sucrose: Roots	Sucrose:Shelton:per 35'	Yellow:	% b/	% b/
	no.	no.	no.	no.	no.	no.	no.	no.
			Lbs.	Tons	%			
SL 126 MS x SP 5460-0	Acc. 2585	1	6151	22.45	13.70	3.5	37.9	2.69
SL (126 x 128)MS x SP 5460-0	Acc. 2586	2	5635	21.01	13.41	4.2	32.3	6.36
SL 126 MS x SP 5822-0	Acc. 2587	3	6124	22.63	13.53	3.0	37.3	5.64
SL (126 x 128)MS x SP 5822-0	Acc. 2588	4	6483	23.68	13.69	3.2	32.2	4.68
SL (129 x 133)MS x SP 5822-0	Acc. 2589	5	6096	21.99	13.86	3.3	32.3	2.10
SP 5822-0	Acc. 2591	6	6086	22.36	13.61	1.5	36.2	6.23
US H2								
60-806-0 (Am #3S Mono) local ck	Acc. 2584	7	5617	21.34	13.16	4.8	34.7	3.51
		8	5706	21.42	13.32	4.3	38.1	6.71
General Mean			5987	22.11	13.54		35.1	
LSD (5% Point)			--	--	.73		--	
F. Value			--	NS	2.37*		NS	
Between Tests			--	*	**		**	
Variety x Location			--	NS	**		NS	
C. V. %			13.43	13.03	3.27		14.88	

Variance Table c/

Source of Variation	D/F	Mean Square (variance)	
		Roots (lbs)	Sucrose %
Between Tests	2	299.57	70.525
Replications	6	62.79	0.730
Varieties	7	57.69	0.465
Variety x Test	14	112.65	0.728
Error	42	72.11	0.196
Total	71	84.31	2.354

a/ Leaf Spot ratings by J. O. Gaskill, September, 1964 (3 replications).

b/ Composite of 3 replications in each of 3 locations--Overton, Shelton and Kearney, Nebraska. Overton not harvested for yield data.

c/ For Gross Sucrose: SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2 + (\text{SE \% sucrose})^2}{(\text{Mean lbs. beets}) (\text{Mean \% sucrose})}}$$

Table 13(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Mason City, Iowa, 1964.

Conducted By: American Crystal Sugar Company.

Location: Mason City, Iowa

Dates of Planting and Harvest: May 11; September 28.

Experimental Design: Triple Lattice, repeated 3 times, 9 replications; plots 1 row x 35'; rows 22" apart.

Determination of Root Yield: Complete plot.

Determination of Sucrose Percentage: Beets from the complete plot were divided into two equal samples for sucrose determination.

Stand Counts: Harvested beets counted when weighed.

Leaf Spot Exposure: Leaf spot readings were taken from the disease nursery. Experimental test was relatively free of leaf spot.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: The beets were extremely dry during part of the season and extremely wet just before harvest.

Reliability of Test: Good.

Table 13(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Mason City, Iowa, 1964 (9-plot averages).

Description	Ft. Col. : seed : no.	Entry : no.	Acre Yield		Roots : Tons	Sucrose		Leaf : spot : per 35'	Stand : (Roots : per 35')
			Lbs.	Gross		%	%		
SL 126 MS x SP 5460-0	Acc. 2585	1	3968		14.63	13.56	4.0	43.6	
SL (126 x 128) MS x SP 5460-0	Acc. 2586	2	4038		15.09	13.38	3.5	35.9	
SL 126 MS x SP 5822-0	Acc. 2587	3	4308		15.84	13.60	2.0	42.6	
SL (126 x 128) MS x SP 5822-0	Acc. 2588	4	3905		14.20	13.75	2.5	35.1	
SL (129 x 133) MS x SP 5822-0	Acc. 2589	5	4172		15.52	13.44	2.5	37.3	
SP 5822-0	Acc. 2591	6	3645		13.64	13.36	1.0	41.0	
US H2	Acc. 2584	7	3752		14.19	13.22	4.5	41.0	
60-806-0 (Am #3S Mono) local ck		8	3956		14.94	13.24	2.0	44.9	
57-GH #5-0 (Am #3S Multi) local ck		9	3979		15.12	13.16	1.5	47.3	
General Mean			3972		14.80	13.42		41.0	
L.S.D. (5% Point)			522		--	--		--	
F. Value			--		NS	NS		NS	
C. V. %			13.92		13.28	4.19		11.85	

Variance Table b/

Source of Variation	D/F	Mean Square (variance)		No. Roots (35')
		Roots (lbs.)	Sucrose %	
Replications	8	95.06	0.9725	63.00
Component a	12	34.44	0.9892	
Component b	6	51.66	0.2950	
Blocks	18	40.18	0.7578	
Varieties	8	38.29	0.3425	115.50
Error (Intra-Block)	46	31.57	0.2598	25.13
Error (Random-Block)	64	--	--	23.62
Total	80	40.53	0.4514	40.75

a/ Leaf spot readings taken from disease nursery.

b/ For Gross Sucrose: SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$$

Table 14(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Hamilton City, California, 1964.

Conducted by: A. Lange and D. D. Dickenson.

Location: M & T Ranch, Hamilton City, California.

Cooperation: Holly Sugar Corporation and M & T Ranch.

Dates of Planting and Harvest: April 4; October 21.

Experimental Design: Latin Square, 9 x 9; plots 2 rows x 53'; rows 30" apart.

Determination of Root Yield: Two rows x 50' in each plot.

Determination of Sucrose Percentage: For each plot, two samples of about 12 beets each (about 30 lbs. per sample).

Stand Counts: Number of beets at harvest time.

Leaf Spot Exposure: Only an occasional spot per leaf.

Curly Top Exposure: None.

Other Diseases: None.

Soil and Seasonal Conditions: Beets were evidently not mature; late planted, harvested early with more than ample N left in the beets.

Reliability of Test: Good.

Table 14(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Hamilton City, California, 1964 (9-plot averages).

Description	:	:	Acre Yield		:	Beets:	
	:Ft. Col.	:Entry:	Gross	:	:Sucrose:	per	:
	:seed no.	: no.:	Sucrose:	Roots	:	:100'	:
			Lbs.	Tons	%	No.	
SL 126 MS x SP 5460-0	Acc. 2585	1	3002	12.775	11.75	188	
SL(126 x 128)MS x SP 5460-0	Acc. 2586	2	3089	12.991	11.89	183	
SL 126 MS x SP 5822-0	Acc. 2587	3	3296	13.518	12.19	183	
SL(126 x 128)MS x SP 5822-0	Acc. 2588	4	3241	13.142	12.33	182	
SL(129 x 133)MS x SP 5822-0	Acc. 2589	5	3300	13.382	12.33	189	
SP 5822-0; LSR check	Acc. 2591	6	1987	7.940	12.51	174	
US H2; CTR check	Acc. 2584	7	4452	17.878	12.45	184	
HH 9; local check		8	5279	19.770	13.35	202	
NBHH 1; local check		9	4930	19.303	12.77	187	
General mean			3620	14.522	12.40	186	
SE mean			145 ^{a/}	0.629	0.32		
SEm/gen. mean (%)			4.01	3.06	2.57		
LSD (5%)			410	1.259	N.S.		

Variance Table

Source of variation	:	:	Mean squares		:
	: D/F	:	Tons roots	: % sucrose	:
Replication	8		10.049	2.012	
Variety	8		128.925	1.243	
Error	64		1.783	0.915	
Total	80				
Calculated F			72.31**	N.S.	

^{a/} Short cut formula.

** Exceeds 1% level (2.70).

NS Not significant.

Table 15(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Nyssa, Oregon, 1964.

Conducted by: The Amalgamated Sugar Company.

Location: Nyssa, Oregon.

Dates of Planting and Harvest: April 8; October 19.

Experimental Design: Latin square, 9 x 9; plots 4 rows wide; 40 ft. long; rows 22 in. apart.

Determination of Root Yield: Weight of roots in two center rows.

Determination of Sucrose Percentage: Ten-root sample from each of two center rows.

Stand Counts: Harvested roots counted when weighed.

Recent Cropping History: 1961, potatoes; 1962, field corn; 1963, sweet corn.

Fertilizer Applied for Beet Crop: 600 lbs. of 24-20-0.

Leaf Spot Exposure: Negligible.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: Growing season shorter than normal because of cool spring and a cool, dry fall. The general crop was down in yields and up in sugar content.

Reliability of Test: Excellent.

Table 15(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Nyssa, Oregon, 1964 (9-plot averages).

Description	Ft. Col.		Entry		Acre Yield		Sucrose		Stand	
	seed	no.	no.	no.	Gross	sucrose	Roots	%	(Roots	per 100')
					Lbs.	Tons			No.	
SL 126 MS x SP 5460-0	Acc. 2585	1			9010	28.44		15.84	82	
SL (126 x 128)MS x SP 5460-0	Acc. 2586	2			8710	27.01		16.12	85	
SL 126 MS x SP 5822-0	Acc. 2587	3			9370	28.75		16.30	87	
SL (126 x 128)MS x SP 5822-0	Acc. 2588	4			8790	27.20		16.16	88	
SL (129 x 133)MS x SP 5822-0	Acc. 2589	5			9630	29.31		16.42	82	
SP 5822-0; LSR check	Acc. 2591	6			7690	24.83		15.49	91	
US H2; CTR check	Acc. 2584	7			9930	30.30		16.39	86	
US 35/2; local check		8			9060	27.30		16.60	91	
S32DR10 (Comm.); local check		9			9940	30.02		16.55	93	

General mean	9120	28.13	16.21	87
S.E. of var. mean	199a/	0.50	0.20	
S. E. of var. mean as % of gen. mean	2.18	1.79	1.25	
L.S.D. (5% level)	560	1.42	0.57	

Variance Table

Source of Variation	D/F	Mean Squares (Variances)	
		Roots (lbs.)	Sucrose %
Varieties	8	1,684.15	1.1455
Rows	8	827.32	5.1845
Columns	8	794.68	0.4311
Error	56	139.93	0.3701
Total	80	428.57	0.9352
Calculated F value		12.04	3.10

a/ S.E. of var. mean calculated from formula.

Table 16(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Goodwell, Oklahoma, 1964.

Conducted by: R. Norton Ford, H. Eugene Reeves, Bill Ott, and Ralph Matlock.

Location: Panhandle Agricultural Experiment Station, Goodwell, Oklahoma.

Cooperation: Oklahoma Agricultural Experiment Station, Holly Sugar Corporation, Great Western Sugar Company, American Crystal Sugar Company, U.S.D.A. Fort Collins, Colorado.

Dates of Planting and Harvest: March 26; October 31.

Experimental Design: Randomized block; 10 replications; plots 3 rows 21', rows 28" apart, center row test variety, 2 rows common border US-35/2; hand trimmed to single plant hills 9" apart.

Determination of Root Yield: All roots in 16' of harvest row were hand topped, cleaned and weighed.

Determination of Sucrose and Thin Juice Purity Percentages: A random sample of roots was taken from the row and taken to Holly Sugar Corp. for analysis.

Recent Cropping History: 1963 castorbeans.

Chemicals Applied for Sugar Beet Crop: 100 pounds of nitrogen applied March 11.

Leaf Spot Exposure: Negligible.

Curly Top Exposure: Severe.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: The 1964 crop season was unusually dry. Adequate soil moisture to prevent severe drought stress was maintained throughout the growing season by means of furrow irrigation. Rainfall from March 1 through October 31 was 8.05 inches.

Table 16(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Goodwell, Oklahoma, 1964 (10-plot averages).

Description	: Ft. Col. :		: Acre yield :		: Thin :		: Curly a/ :	
	: seed	: no.	: Entry:	: Gross :	: Sucrose :	: juice :	: top :	: grade :
			: no. :	: sucrose :	: Roots	: %	: purity :	: grade :
					Tons	%		
SL 126 MS x SP 5460-0	Acc. 2585		1	9604	32.83	14.65	86.0	1.8
SL (126 x 128) MS x SP 5460-0	Acc. 2586		2	9627	32.03	15.17	86.8	2.2
SL 126 MS x SP 5822-0	Acc. 2587		3	9021	29.47	15.27	86.9	2.7
SL (126 x 128) MS x SP 5822-0	Acc. 2588		4	9464	31.61	14.97	86.6	1.9
SL (129 x 133) MS x SP 5822-0	Acc. 2589		5	9487	30.96	15.30	86.6	2.3
SP 5822-0	Acc. 2591		6	3956	12.70	15.63	88.2	6.5
US H2	Acc. 2584		7	9044	31.62	14.25	85.4	1.8
US 35/2 b/				8460	28.38	14.85	83.2	1.4
AH2 b/				9371	32.48	14.49	83.7	1.2
62-4T33H(2X) b/				10818	38.24	14.30	84.3	1.4
HH7 c/				10152	35.34	14.39	84.0	1.8
HH10 c/			8	10211	34.30	14.98	85.2	2.8
HH12 c/			9	7655	25.94	14.93	84.5	3.9
63H6 d/				8589	29.42	14.67	83.5	2.9
62MSH200 d/				9581	31.24	15.38	85.6	2.5
General Mean				9003	30.4	14.88	85.4	2.5
C.V. (%)				18.9	18.04	7.36		

Variance Table

Source of Variation	D/F	Mean square (variance) and Calculated F values			
		Gross sucrose (lbs.)	F	Roots (tons)	Sucrose %
Replications	9	1.62	.75	150.99	8.16
Treatments (varieties)	14	18.62	8.58**	958.18	1.76
Error (remainder)	126	2.17		89.57	1.14
Total	149				

a/ Basis of curly top grades: 0 = healthy; 9 = death due to curly top.

Seed furnished by American Crystal Sugar Company.

c/ Seed furnished by Holly Sugar Corporation.

d/ Seed furnished by Great Western Sugar Company.

Table 17(a).--Description of cooperative agronomic evaluation test of
LSR-CTR varieties, Hereford, Texas, 1964.

Conducted by: Paul Scott, Holly Sugar Corporation.

Location: Eddie Reinauer farm, Hereford, Texas.

Dates of Planting and Harvest: March 22; October 20.

Experimental Design: Latin Square, 9 x 9; plots 2 rows x 54'; rows
30" apart.

Determination of Root Yield: 2 rows x 50'.

Determination of Sucrose Percentage: Two 15-beet samples per plot.

Previous Crops: 1962, onions and lettuce; 1963, potatoes.

Fertilizer: 500# 21-0-0; 500# 0-20-0; 10 tons manure.

Leaf Spot Exposure: Negligible.

Curly Top Exposure: Severe.

Other Diseases and Pests: Negligible.

Reliability of Test: Very good.

Table 17(b).--Results of cooperative agronomic evaluation test of LSR-CTR varieties, Hereford, Texas, 1964 (9-plot averages except as indicated).

Description	: Ft. Col. :		: Acre yield :		: Sucrose :		: Beets :	
	: seed :	: Entry :	: Gross :	: no. :	: sucrose :	: Roots :	: top :	: per :
	: no. :	: no. :	: lbs. :			: Tons :	: % :	: 100' :
SL 126 MS x SP 5460-0	Acc. 2585	1	6120	21.001	14.57	1.8	155	
SL(126 x 128)MS x SP 5460-0	Acc. 2586	2	6452	21.960	14.69	2.0	158	
SL 126 MS x SP 5822-0	Acc. 2587	3	6513	22.245	14.64	2.0	158	
SL(126 x 128)MS x SP 5822-0	Acc. 2588	4	6193	21.369	14.49	1.8	156	
SL(129 x 133)MS x SP 5822-0	Acc. 2589	5	6307	21.705	14.53	2.3	158	
SP 5822-0; LSR check	Acc. 2591	6	3898	12.941	15.06	5.5	136	
US H2; CTR check	Acc. 2584	7	6354	21.466	14.80	1.0	161	
HH 10; local check		8	6066	21.223	14.29	2.8	155	
HH 12; local check		9	5646	18.859	14.97	2.0	152	
General mean			5950	20.308	14.67		154	
S.E. mean			182 b/	0.554	0.20			
S.E.M. as % of gen. mean			3.06	2.73	1.38			
Sig. difference (5%)			517	1.573	N.S.			

Variance Table

Source of variation	: D/F :		: Mean squares :	
	: :	: Tons roots :	: Percent sucrose :	
Rows	8	36.47	2.51	
Columns	8	3.84	0.42	
Varieties	8	77.16	0.52	
Residual	56	2.76	0.37	
Total	80	13.68	0.60	
Calc. F value		27.95**	N.S.	

a/ Curly top grades, 9/24/64, 2-plot averages, J. O. Gaskill. Basis of grades: 0 = healthy; 9 = death due to curly top.

b/ S.E.M. calculated from formula.

** Exceeds 1% point of significance (2.88).

Table 18(a).--Description of cooperative agronomic evaluation test of LSR-CTR varieties, Artesia, New Mexico, 1964.

Conducted by: W. J. Russell.

Location: Southeastern Branch Station, New Mexico Agricultural Experiment Station, Artesia, New Mexico.

Cooperation: New Mexico Agricultural Experiment Station.

Dates of Planting and Harvest: March 28; October 29.

Experimental Design: Balanced lattice design (K + 1 Replications); two double-row beds per plot, beds 40" apart; rows 22' long; hand thinned to single-plant hills. Analyzed as a randomized complete block.

Determination of Root Yield: Ten feet of two rows per plot.

Determination of Sucrose Percentage: All roots harvested for root yield in each plot. The pulp was frozen and sent to Holly Sugar Corporation for laboratory analysis. Refractometer readings were made prior to freezing the pulp for comparison with laboratory analysis.

Stand Counts: Harvested beets counted when weighed.

Recent Cropping History: Winter Barley 1962-63.

Fertilizers Applied for 1964 Crop: Broadcast 77 pounds nitrogen and 37 pounds P_2O_5 per acre prior to bed preparation; sidedressed 73 pounds nitrogen and 35 pounds P_2O_5 per acre on June 8, 1964.

Leaf Spot Exposure: Moderately severe after September 1.

Curly Top Exposure: Extremely severe.

Other Diseases and Pests: Negligible.

Soil and Seasonal Conditions: The 1964 crop season was hot and dry. All plots were irrigated the day of planting. Subsequent irrigations were made at approximately two week intervals up to September 21 for a total of 14 irrigations.

Remarks: The test was planted adjacent to a winter planting of sugar beets, and consequently, overwintering leaf hoppers caused an early infection of curly top.

Table 18(b). --Results of cooperative agronomic evaluation test of LSR-CIA varieties, Artesia, New Mexico, 1964 (4-plot averages).

Description	:Ft. Col.:		:Acre Yield		:Refract-:Sucrose:Leaf ^a :/Curly ^b /Stand				
	: seed	: Entry:	: Gross :	: ometer :	: spot :	: Top :			
	: no.	: no.	: sucrose:	: Roots :	: 9/25	: (plants)			
			Lbs.	Tons	%	%	No.		
SL 126 MS x SP 5460-0	Acc. 2585	1	5758	17.24	18.90	16.7	1.1	3.2	1.61
SL(126 x 128)MS x SP 5460-0	Acc. 2586	2	5618	16.62	19.75	16.9	1.0	3.8	1.50
SL 126 MS x SP 5822-0	Acc. 2587	3	6307	18.02	20.40	17.5	0.6	2.8	2.01
SL(126 x 128)MS x SP 5822-0	Acc. 2588	4	6164	17.51	20.75	17.6	0.8	2.8	1.65
SL(129 x 133)MS x SP 5822-0	Acc. 2589	5	7004	20.48	19.85	17.1	0.5	2.8	1.64
SP 5822-0	Acc. 2591	6	1280	3.72	21.25	17.2	0.5	6.2	1.28
US H2	Acc. 2584	7	7021	21.94	17.55	16.0	1.8	1.6	2.21
SP 6051-0; local check	SP 631210H0	8	4725	16.18	16.50	14.6	0.5	1.0	1.91
HH-10; local check		9	6183	20.34	20.55	15.2	0.6	3.8	2.08
General mean			5562	16.89	19.50	16.5	0.8	3.1	1.76
L.S.D. (5% point)				2.82	1.71	n.s.		0.8	
L.S.D. (1% point)				3.82	2.32	n.s.		1.1	
Coef. of var. (%)				11.42	6.01	9.7		17.9	

Analyses of Variance

Source of Variation	df	Refractometer		Root Yield	
		Mean Square	F	Mean Square	F
Replicates	3	2.38	1.73	17.65	4.74**
Entries	8	9.94	7.24**	113.00	30.34**
Error	24	1.37		3.72	
Total	35				

a/ Leaf Spot: 0 = healthy; 9 = all leaves dead (W. J. Russell).

b/ Curly Top: 0 = healthy; 9 = dead (C. L. Schneider).

* Significant at the 5% level.

** Significant at the 1% level.

Table 19 --Cooperative agronomic evaluation test of LSR-CTR varieties, Beltsville, Maryland, 1964
(3-plot averages). a/

Description	: Ft. Col. :		: Acre yield :		: Leaf spot b/ :		: Roots :	
	: seed no. :	: Entry no. :	: Gross : Lbs.	: sucrose : Tons	: Sucrose : %	: 8/5 : 8/20 :	: per 80 : sq. ft.:	: No.
SL 126 MS x SP 5460-0	Acc. 2585	1	5157	19.75	13.03	2.9	3.8	31
SL (126 x 128) MS x SP 5460-0	Acc. 2586	2	5216	20.55	12.70	3.0	3.4	32
SL 126 MS x SP 5822-0	Acc. 2587	3	5477	21.25	12.90	2.8	3.6	31
SL (126 x 128) MS x SP 5822-0	Acc. 2588	4	5496	20.50	13.40	3.0	3.8	31
SL (129 x 133) MS x SP 5822-0	Acc. 2589	5	4840	18.39	13.17	2.8	3.3	30
SP 5822-0; LSR check	Acc. 2591	6	6112	22.04	13.87	2.1	2.0	30
US H2; CTR check	Acc. 2584	7	3459	15.48	11.17	2.9	4.3	29
SP 6351-0; local check		8	5195	20.66	12.57	2.4	2.8	28
General mean			5119.21	19.829	12.850			
S.E. of var. mean			220.44	0.708	0.303			
S.E. of var. mean as % of gen. mean			4.31	3.57	2.36			
L.S.D. (5% point)			669	2.15	0.92			

Variance Table

Source of variation	: D/F :	: Mean square (variance) :	
		: Gross sucrose : Roots	: Sucrose % :
Replications	2	115,786	2.0984
Varieties	7	1,760,071	12.6747
Error (remainder)	14	145,792	1.5048
Total	23		
Calc. F value		12.07**	8.42**
			6.85**

a/ Test conducted by G. E. Coe, U. S. Department of Agriculture; randomized-block design; plots 80 sq. ft. in size.

b/ Leaf spot grades: 0 = no leaf spot; 10 = complete defoliation.

** Exceeds the 1% point (4.28).

Table 20 •--Cooperative curly top resistance evaluation test of LSR-CTR varieties under field conditions, Thatcher, Utah, 1964. a/

Description	Ft. Collins seed no.	Entry no.	% Curly top		C.T. grade ^{b/} 10/7	No. beets per 100' of row
			8/6	8/20		
US 41; CTR check			8.1	33.7	4	80
US 33; CTR check			38.7	67.1	5.5	81
SL 126 MS x SP 5460-0	Acc. 2585	1	18.1	43.2	4	100
SL (126 x 128) MS x SP 5460-0	Acc. 2586	2	20.5	47.6	4	83
SL 126 MS x SP 5822-0	Acc. 2587	3	26.9	52.7	5	91
SL (126 x 128) MS x SP 5822-0	Acc. 2588	4	21.6	49.3	4.5	100
SL (129 x 133) MS x SP 5822-0	Acc. 2589	5	21.8	56.3	5	92
SP 5822-0; LSR check	Acc. 2591	6	37.1	63.5	6.5	84
US H2; CTR check	Acc. 2584	7	13.9	39.4	3	83
US 41; CTR check			17.5	34.6	4	86
US 33; CTR check			32.8	61.3	5	93

a/ Test conducted by Albert M. Murphy, U. S. Department of Agriculture.

b/ Results based on two replications for each entry. Basis of curly top grades:
0 = healthy; 9 = death due to curly top.

NOTE: The crop was planted on June 27, and moderate curly top exposure was promoted by artificial means. The plots were 2 rows, planted 22 inches apart and 50 ft. long in 2 replications.

Table 21 --Cooperative curly top resistance evaluation tests of LSR-CTR varieties, in the greenhouse, Logan, Utah, 1964.^{a/}

Description	Fort			Test I <u>b/</u>		Test II <u>b/</u>		
	Collins	Entry:	Plants:	CT severity	Plants:	CT severity		
	seed	no.	with	Actual <u>c/</u> : % of	with	Actual <u>c/</u> : % of		
	no.		: CT (%)	: US 41 <u>d/</u> : CT (%)		: US 41 <u>d/</u> :		
SL 126 MS x SP 5460-0	Acc. 2585	1	75	5.4	100	50	5.8	105
SL (126 x 128)MS x SP 5460-0	Acc. 2586	2	60	5.6	104	75	5.9	107
SL 126 MS x SP 5822-0	Acc. 2587	3	50	6.4	119	85	6.2	113
SL (126 x 128)MS x SP 5822-0	Acc. 2588	4	60	5.4	100	75	6.3	115
SL (129 x 133)MS x SP 5822-0	Acc. 2589	5	60	6.1	113	65	6.8	124
SP 5822-0; LSR check	Acc. 2591	6	85	6.6	122	70	8.1	147
US H2; CTR check	Acc. 2584	7	70	4.2	78	65	5.2	95
US 22/4; CTR check						50	4.8	87
US 33; check (low CTR)						70	7.2	131
US 41; CTR check ("standard")			65	5.4	100	75	5.5	100

a/ Tests conducted by C. L. Schneider, U. S. Department of Agriculture, using small seedlings with one caged leafhopper per plant and curly top virus culture no. ALA (about equal to strain 11 in virulence).

b/ Results expressed as means for five 6-inch pots, each containing 4 plants.

c/ Basis of curly top severity grades: 0 = no symptoms; 9 = dead. Plants without curly top symptoms were disregarded in computing averages.

d/ Values less than 100 indicate less curly top injury than in US 41; values greater than 100 indicate more severe injury than in US 41.

P A R T VI

DEVELOPMENT OF BREEDING METHODS

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POPULATION GENETICS

Foundation Project 25

LeRoy Powers

R. J. Hecker

Research conducted in cooperation with the Colorado Agricultural
Experiment Station

PROGRESS REPORT TO THE BEET SUGAR DEVELOPMENT FOUNDATION ON THE GENETIC
AND PLANT BREEDING PHASES OF PROJECT NUMBER 25 1/, 2/, 3/, 4/

By LeRoy Powers and Richard J. Hecker

Selection and Combining Ability Studies

The purposes of these studies were to determine the effectiveness of selection in shifting the means of segregating populations as regards weight per root and percentage sucrose, and to determine the combining ability of the selections. The frequency distributions, means and their standard errors for weight per root are listed in table 1. These were grown to determine which population appeared to be the most promising for making selections for weight per root. The number of individuals per population is 320.

A study of the frequency distributions of table 1 reveals that populations A56-3 and 52-407 X 54-565 F_2 have the greater number of individuals in the higher weight classes. The mean weight per root of A56-3 is about twice that of the mean weight per root of 52-407 X 54-565 F_2 , yet the extreme segregates of this latter population compare rather favorably with the extreme segregates of A56-3. Further, 52-407 X 54-565 F_2 has 11 plants heavier than the comparable 54-565 X 52-407 F_1 . Also, this same comparison holds for the two inbred parents. It seems that these 11 plants show transgressive segregation beyond the parents and F_1 . Hence, the genes differentiating weight per root would be expected to be cumulative in action and comparatively few in number.

- 1/ The breeding and genetic phases of Project 25 are cooperative with the Agronomy and Chemistry Departments of the Colorado State University Agricultural Experiment Station, the Mathematics Department of Colorado State University, and the Beet Sugar Development Foundation.
- 2/ Acknowledgments are due the Western Data Processing Center at the University of California at Los Angeles for use of the computing facilities for analyzing data, Job Number 1081.
- 3/ The writers are indebted to R. Ralph Wood of the Great Western Sugar Company for obtaining thin-juice samples by an oxalate method standard with his company, and for purity determinations.
- 4/ Figures in parentheses refer to literature cited.

Table 1.—Frequency distributions, means and their standard errors for weight per root in kilograms, selection and combining ability studies, 1953.

Type of population, population, and entry number	Upper limit of class in kilograms														Mean and standard error	
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8		Over 2.8
Kg																
Non-homogeneous																
A56-3, 5	14	25	30	34	37	50	38	17	17	16	14	3	9	4	12	1.179±0.0360
52-407 X 54-565, F ₂ , 7	30	98	89	59	20	7	5	1	4	2	2	1	2			0.544±0.0192
54-403 X 52-407, F ₂ , 8	28	84	92	72	22	15	5	2								0.535±0.0132
54-403 X 54-565, F ₂ , 9	46	116	99	37	17	3	2									0.424±0.0109
Homogeneous																
54-565, 1	135	159	25	1												0.234±0.0051
52-407, 2	25	52	101	84	42	15	1									0.572±0.0117
54-403, 3	122	180	18													0.242±0.0046
54-565 X 52-407, F ₁ , 4	5	40	89	91	54	28	11	2								0.687±0.0127
54-403 X 54-565, F ₁ , 6	14	59	82	77	50	27	8	2	1							0.641±0.0139

In order to eliminate the usual positive relation (see Powers et al. 3) ^{4/} between the means and variances the data were transformed to logarithms, and the genetic variances were calculated. The means of the logarithms together with the variances and heritability ratios are listed in table 2. Both the genetic variances and heritability ratios are significantly higher for A56-3 than for 52-407 X 54-565 F_2 . However, the genetic variance and heritability ratios are higher for the F_2 population of 52-407 X 54-565 than for the other F_2 populations.

Table 2.--Means and genetic variances for weight per root, selection and combining ability studies, 1959, data transformed to logarithms. ^{1/}

Type of population, population, and entry number	Mean	Within plot variance		Herit- ability ratio
		Total	Genetic	
<hr/>				
	Log(kg)			
<hr/>				
Non-homogeneous				
A56-3, 5	-0.022347	0.106219	0.063729	0.600
52-407 X 54-565, F ₂ , 7	-0.347154	0.073309	0.030819	0.420
54-403 X 52-407, F ₂ , 8	-0.331117	0.055938	0.013448	0.240
54-403 X 54-565, F ₂ , 9	-0.436525	0.062797	0.020307	0.323
 Homogeneous				
54-565, 1	-0.678908	0.043581		
52-407, 2	-0.296522	0.053426		
54-403, 3	-0.661796	0.037812		
54-565 X 52-407, F ₁ , 4	-0.199906	0.032973		
54-403 X 54-565, F ₁ , 6	-0.243827	0.044658		
 Average, estimated environmental				
		0.042490		

^{1/} Degrees of freedom are 280 for each population and hence are 5 X 280, or 1400 for the estimated environmental variance.

The frequency distributions, means and their standard errors for percentage sucrose are listed in table 3. The means together with the genetic variances and heritability ratios for percentage sucrose listed in table 4 furnish the most information. From table 3 it can be seen that the means for percentage sucrose for the two corresponding inbreds (54-565 and 54-403), 54-403 X 54-565 F_1 and 54-403 X 54-565 F_2 are 14.06, 14.37, 14.44 and 14.36. The differences comparatively speaking are not great, which might be taken as indicating that the genes controlling the production of sucrose in these inbreds and their hybrids do not differ greatly in number and effect. In other words, that inbreds 54-403 and 54-565 do not differ materially in the genes controlling sucrose production. If such were true, then the means of the two F_2 populations, 52-407 X 54-565 and 54-403 X 52-407, would not be expected to differ substantially. Such is not the case, as the mean percentage sucrose (12.64) for the 52-407 X 54-565 F_2 is considerably less than the mean percentage sucrose (13.35) for the 54-403 X 52-407 F_2 . That the inbreds 54-403 and 54-565 do differ greatly as regards the genes controlling percentage sucrose is confirmed by the fact that the genetic variance and heritability ratio for the 54-403 X 54-565 F_2 is considerably larger than those for the F_2 populations 52-407 X 54-565 and 54-403 X 52-407 (see table 4).

Table 3.—Frequency distributions, means and their standard errors for percentage sucrose, selection and combining ability studies, 1959.

Type of population, population, and entry number	Upper limit of class in percent														Mean and standard error
	8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00	15.75	16.50	17.25	18.00	
Non-homogeneous															
A56-3, 5	2	1	5	21	17	50	57	78	43	32	13	0	0	1	12.71±0.074
52-407 X 54-565, F ₂ , 7			3	13	26	62	73	73	31	26	12	0	1		12.64±0.058
54-403 X 52-407, F ₂ , 8			2	3	11	34	51	80	63	49	16	8	3		13.35±0.060
54-403 X 54-565, F ₂ , 9	2	1	0	2	3	5	14	53	62	66	70	35	7		14.36±0.064
Homogeneous															
54-565, 1					4	14	22	55	82	83	41	17	2		14.06±0.049
52-407, 2	1	7	25	76	99	75	31	4	2						10.90±0.036
54-403, 3			1	1	0	6	13	39	73	108	52	21	6		14.37±0.047
54-565 X 52-407, F ₁ , 4				8	24	92	78	20	5						12.33±0.037
54-403 X 54-565, F ₁ , 6						4	13	38	82	104	50	22	1		14.44±0.042

Table 4.--Means and genetic variances for percentage sucrose, selection and combining ability studies, 1959, data transformed to logarithms. 1/

Type of population population, and entry number	Mean	Within plot variance		Herit- ability ratio
		Total	Genetic	
	Log(%)			
Non-homogeneous				
A56-3, 5	1.100468	0.003174	0.002374	0.748
52-407 X 54-565, F ₂ , 7	1.099460	0.001576	0.000776	0.492
54-403 X 52-407, F ₂ , 8	1.123264	0.001577	0.000777	0.492
54-403 X 54-565, F ₂ , 9	1.154516	0.002038	0.001238	0.607
Homogeneous				
54-565, 1	1.146555	0.000967		
52-407, 2	1.035745	0.000828		
54-403, 3	1.156181	0.000862		
54-565 X 52-407, F ₁ , 4	1.089718	0.000687		
54-403 X 54-565, F ₁ , 6	1.158488	0.000658		
Average, estimated environmental		0.000800		

1/ Degrees of freedom are 280 for each population variance and hence are 5 X 280, or 1400 for the estimated environmental variance.

The identifiable numbers of genetic deviates in sections 4, 5, and 6 of the bivariate frequency distribution for weight per root and percentage sucrose are listed in table 5. A study of table 5 reveals that the numbers in sections 4 and 6 are greater than zero. The number 6 in section 5 for A56-3 is significantly different from zero, also. Again the identifiable number of genetic deviates indicates that selection in A56-3 would be the most effective. The F_2 populations do not differ materially in the identifiable number of genetic deviates. It was decided to make selections in the F_2 of 52-407 X 54-565, because the eleven plants of this population falling beyond the 1.6 class averaged 3.7 times the corresponding F_2 mean in weight per root. Also, transgressive segregation was shown to be occurring in this population. Hence, it seemed quite probable that selection in this population for higher weight per root would be effective in shifting the mean towards heavier roots.

Table 5.--Identifiable numbers of genetic deviates and their standard errors in sections 4, 5, and 6 of the bivariate frequency distribution for weight per root and percentage sucrose for the segregating populations grown in 1959.

Population and entry number	Section			Total identifiable genetic deviates
	4	5	6	
	High weight, average sucrose	High weight, high sucrose	Average weight, high sucrose	
A56-3	18±4	6±2	23±5	47±6
52-407 X 54-565, F_2	9±3	1±1	15±4	25±5
54-403 X 52-407, F_2	5±2	2±1	14±4	21±4
54-403 X 54-565, F_2	13±4	3±2	10±3	26±5

In 1961 studies were made which included 10 populations. These were grown in a randomized complete block consisting of 40 replications and 12 plants per replication. The frequency distributions and population means for weight per root together with their standard errors are listed in table 6. The corresponding data for percentage sucrose are listed in table 7. The frequency distributions have been adjusted to eliminate differences between replication means and to eliminate differences between population means and hence are directly comparable. The data were transformed to logarithms to do away with possible positive relation between the means and variances. The means and standard errors in both tables 6 and 7 are for the nontransformed and nonadjusted data. The data for 1961 confirm that for 1959, in that the F_2 hybrid 52-407 X 54-565 shows transgressive segregation for weight per root as more plants of the F_2 are found in the higher classes than are those of either the parental or the F_1 populations. Hence, it seems that selection within the F_2 might be effective in increasing weight of root per plant. As a study of table 7 shows the F_2 generation compares favorably with the F_1 in plants falling in the higher classes as regards percentage sucrose. However, it should be pointed out that the mean of the inbred parent (54-565) is considerably higher in percentage sucrose than the mean of the F_2 . Clearly, the F_2 is not showing transgressive segregation for percentage sucrose.

Table 7.—Frequency distribution and means and their standard errors for percentage sucrose, selection and combining ability studies, 1961.

Type of population, population, and entry number	Upper limit of class in percent														Mean and standard error	
	8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00	15.75	16.50	17.25	Over 18.00		
Non-homogeneous																
A56-3, 10	3	3	1	4	13	17	25	50	61	93	58	63	45	34	10	14.75±0.077
52-407 X 54-565, F ₂ , 4			3	5	14	22	35	53	48	77	67	75	29	38	14	14.74±0.066
Homogeneous																
54-565 X 52-407, F ₁ , 3				3	5	17	25	52	69	97	85	74	37	14	2	14.73±0.047
52-305 C _{MS} X 54-565, F ₁ , 5						1	5	13	41	62	79	110	86	60	22	15.94±0.043
52-305 C _{MS} X 52-407, F ₁ , 1		1	1	5	8	32	42	88	73	85	62	42	21	13	7	14.20±0.051
52-305 C _{MS} X 52-305 M _F , 6						1	5	16	57	66	68	80	88	53	47	15.24±0.048
52-407, 7	4	17	21	47	80	97	75	72	35	24	7	1				11.86±0.046
54-565, .				1	0	1	2	4	12	49	76	140	97	73	25	16.27±0.045
52-305 M _F , 9					2	6	14	30	53	83	84	103	61	25	17	15.42±0.045

For the purposes of making selections, 24 plots consisting of 12 rows per plot and a potential of 24 plants per row were grown in 1961. This makes a total potential of 6912 plants used in the selection experiment. When the plants were in the five-leaf stage some were selected on the basis of vigor and staked for further observation during the growing season. As the season progressed some of these plants were discarded and were replaced by others appearing to have more promise as regards weight per root. This procedure was followed throughout the growing season and the final selection of 551 roots on the basis of weight per root was made at the time of harvest. These 551 roots were taken into the laboratory and reselected on the basis of both weight per root and percentage sucrose. A total of 64 beets were saved. The seven with the best rating were halved and one of the halves of each was included in the isolation plot with the 57, making a total of 64 beets. The other half of each was included in a separate isolation plot. Also from this selection plot of potentially 6912 plants, 55 beets were taken at random, no selection being practiced. In 1962 these three populations were grown in three isolation plots together with the following cytoplasmic male sterile lines: 52-305, NB1, and NB5. This provided four different seed lots from each of these three isolations. The hybrid seed for testing combining ability was harvested separately from each of the female parents (52-305 CMS, NB1 CMS, and NB5 CMS) and was harvested separately from each male parent in each of the three isolation plots. The seed from the male parent provided populations resulting from open pollination of the best 7 plant selection, the 64 plant selection, and the 55 plants taken at random. This provided a total of 12 different populations to which two checks of A56-3 were added, making a total of 14 entries of 13 different populations. The two checks were identical populations but carried different entry numbers, serving as duplicate entries. In 1963 these 14 entries were grown in a complete randomized block design composed of 30 replications, and 15 plants were harvested per plot, making a total of 450 plants for each entry.

The means for weight per root and percentage sucrose showing the combining ability of the selections and random sample for the F_2 of 54-565 X 53-407 grown in 1963 are listed in table 8. As regards weight per root the 7 best plants, the 64 plant selection, and the 55 plants taken at random do not differ significantly in combining ability when 52-305 CMS and NB1 CMS are used as tester. For percentage sucrose the selection of 64 plants is lower when tested with 52-305 CMS and NB1 CMS than are the 7 best plants and the 55 plants taken at random. When tested with NB5 CMS the 7 best plants are lower in combining ability for weight per root than are the 64 plant selection and the 55 plants taken at random. The latter two do not differ significantly when tested by NB5 CMS as regards combining ability for weight per root. For percentage sucrose the 7 best plant selection is highest in combining ability when tested with NB5 CMS, the 64 plant selection is second, and the 55 plants taken at random is last.

Table 8.--Weight per root and percentage sucrose means and their standard errors for combining ability studies with selections and random sample from F₂ of 54-565 X 52-407, 1963. 1/

Female parent	Weight per root, male parent			Percentage sucrose, male parent		
	7 plants, best	64 plants	55 plants, random	7 plants, best	64 plants	55 plants, random
	K _F	K _F	K _G	%	%	%
52-305 C'S	0.94±0.017	0.94±0.018	0.93±0.019	17.5±0.040	17.3±0.045	17.5±0.042
NE1 C'S	1.13±0.022	1.16±0.022	1.18±0.026	17.0±0.042	16.7±0.047	17.1±0.053
NE5 C'S	1.10±0.022	1.19±0.024	1.23±0.025	16.6±0.049	16.5±0.048	16.3±0.055
F ₂ , open pollinated	0.77±0.014	0.69±0.013	0.72±0.019	16.6±0.052	16.7±0.057	15.8±0.064

1/ The weight per root of A56-3 (check) is 1.10±0.018 and the percentage sucrose is 17.5±0.035.

The populations resulting from open pollination of the F₂ plants show that in weight of root per plant selection of the 7 best phenotypes resulted in an increase in weight per root of 7 percent over the 55 plants taken at random and an increase of 12 percent over the selection of the 64 best phenotypes. There is a decrease in percentage sucrose but the differences are not significant at the five percent level. Hence, selection of the 7 best plants resulted in an increase in weight per root as had been indicated would be the case by the population genetic studies conducted in 1959 and 1961. This was not true of the combining ability of the 7 best plants selected when NB5 was used as the tester parent. In fact the 7 best plants were lower in combining ability in this case than either 55 plants taken at random or the 64 plant selection. It can be concluded, if we were successful in isolating, by selection, those genes showing transgressive segregation that these same genes are not necessarily conducive to high combining ability.

The data shown in table 8 were taken on an individual plant basis. These individuals were classified, for each population, as to root and hypocotyl color. There were four phenotypic classes as follows: [1] red root and red hypocotyl, [2] yellow root and yellow hypocotyl, [3] white root and red hypocotyl, and [4] white root and green hypocotyl. Lindhard and Iversen (2) and Keller (1) have shown that in some material at least that two pairs of genes [RrYy] differentiate the above phenotypic classes. The number of individuals falling in each class for the 13 populations included in this study are listed in table 9. The yellow rooted parent 54-565 occasionally produced some white rooted progeny, all plants not being homozygous for the Y gene.

Table 9.--Number of individuals for populations classified on the basis of root color and hypocotyl color (red root and red hypocotyl, yellow root and yellow hypocotyl, white root and red hypocotyl, and white root and green hypocotyl), combining ability studies with selections and random sample from F₂ of 54-565 X 52-407, 1963.

Population	Red root and red hypocotyl	Yellow root and yellow hypocotyl	White root and red hypocotyl	White root and green hypocotyl
7 best plants, selection				
52-305 CMS	172	278		
NB1 CMS	225	224		1
NB5 CMS	215	233	2	
F ₂ , open pollinated	291	159		
64 plants, selection				
52-305 CMS	256	194		
NB1 CMS	254	194		2
NB5 CMS	212	236		2
F ₂ , open pollinated	347	103		
55 plants, random sample				
52-305 CMS	182	237	30	1
NB1 CMS	198	222	30	
NB5 CMS	256	162	29	3
F ₂ , open pollinated	302	143	3	2
A56-3, checks combined			755	145

First consider the yellow rooted and yellow hypocotyl color segregates of the different populations. All populations of the seven best plant selections and of the 64 plant selections has greater weights per root than the corresponding populations of the 55 plants taken at random. These differences in favor of the selections range from 2 to 16 percent and are too consistent to be attributed to random sampling. This is especially true since by the t-test some of the differences are significant at the five percent level. For the red rooted and red hypocotyl segregates of the populations involving NB1 CMS and NB5 CMS as the female parents, the populations having the 55 plants taken at random as the male parent are consistently higher in weight per root than those having the selections (7 best plants and 64 plants) as the male parent. Again, some of these comparisons are statistically significant at the five percent level and represent increases from 4 to 17 percent. Hence, it appears that selection lowered the combining ability for weight per root of the red rooted and red hypocotyl segregates when NB1 and NB5 are used as testers.

An examination of the data in tables 10 and 11 show that, in general, there is a negative association between weight of root per plant and percentage sucrose. However, this is not absolute as is shown by the comparison of NB1 CMS as the tester with NB5 CMS as the tester for the 55 plant random sample. In going from a root weight of 1.09 to 1.62 kilograms for NB1 as the tester the decrease in percentage sucrose is 0.63 percent, whereas, in going from a root weight of 1.09 to 1.56 kilograms for NB5 as the tester the decrease in percentage sucrose is 1.01 percent. Also, in going from a root weight of 1.09 in the commercial variety to a root weight of 1.19 there is no corresponding decrease in percentage sucrose; e.g., 17.47 percent compared with 17.53 percent. Again the root weights of the F₂ open pollinated for the 7 best plants, the 64 plants, the 55 plant random sample and the white-root green-hypocotyl plants of A56-3 are 0.71, 0.70, 0.61 and 1.19 kilograms; whereas the corresponding percentages of sucrose are 16.99, 16.98, 17.46 and 17.53. To what extent high weight per root and high percentage sucrose can be recombined is not revealed by these data. However, it is evident that the maximum has not been reached for either character and that fundamental studies involving genetic mapping of the chromosomes would be of considerable value in providing fundamental information.

The means and standard errors of weight per root for plants of populations classified on the basis of root color and hypocotyl color are listed in table 10. These data were taken from combining ability studies conducted in 1963.

Table 10.--Means and standard errors of weight per root for populations classified on the basis of root color and hypocotyl color (red root and red hypocotyl, yellow root and yellow hypocotyl, white root and red hypocotyl, and white root and green hypocotyl) combining ability studies with selections and random sample from F₂ of 54-565 X 52-407, 1963.

Population	Phenotype of root and hypocotyl			
	Red root and red hypocotyl	Yellow root and yellow hypocotyl	White root and red hypocotyl	White root and green hypocotyl
	Kg	Kg	Kg	Kg
7 best plants, selection				
52-305 CMS	1.02±0.030	0.89±0.021		
NB1 CMS	1.14±0.032	1.12±0.032		
NB5 CMS	1.09±0.032	1.11±0.030		
F ₂ , open pollinated	0.80±0.019	0.71±0.021		
64 plants, selection				
52-305 CMS	0.97±0.023	0.91±0.028		
NB1 CMS	1.16±0.029	1.17±0.033		
NB5 CMS	1.18±0.035	1.21±0.032		
F ₂ , open pollinated	0.69±0.015	0.70±0.028		
55 plants, random sample				
52-305 CMS	0.97±0.032	0.85±0.021	1.29±0.071	
NB1 CMS	1.21±0.040	1.09±0.032	1.62±0.101	
NB5 CMS	1.28±0.033	1.09±0.038	1.56±0.105	
F ₂ , open pollinated	0.75±0.025	0.61±0.021		
A56-3, checks combined			1.09±0.019	1.19±0.048

Table 11.--Means and standard errors of percentage sucrose for populations classified on the basis of root color and hypocotyl color (red root and red hypocotyl, yellow root and yellow hypocotyl, white root and red hypocotyl, and white root and green hypocotyl), combining ability studies with selections and random sample from F₂ of 54-565 X 52-407, 1963.

Population	Percentage of root and hypocotyl			
	Red root and red hypocotyl	Yellow root and yellow hypocotyl	White root and red hypocotyl	White root and green hypocotyl
	%	%	%	%
7 best plants, selection				
52-345 CMS	17.37±0.068	17.55±0.048		
NB1 CMS	16.85±0.059	17.25±0.057		
NB5 CMS	16.55±0.076	16.70±0.060		
F ₂ , open pollinated	16.31±0.064	16.99±0.078		
64 plants, selection				
52-375 CMS	17.19±0.061	17.43±0.063		
NB1 CMS	16.63±0.063	16.83±0.071		
NB5 CMS	16.26±0.077	16.63±0.060		
F ₂ , open pollinated	16.66±0.064	16.98±0.126		
55 plants, random sample				
52-305 CMS	17.26±0.065	17.75±0.054	17.06±0.181	
NB1 CMS	17.04±0.075	17.14±0.080	16.51±0.187	
NB5 CMS	16.13±0.068	16.74±0.093	15.73±0.299	
F ₂ , open pollinated	16.55±0.074	17.46±0.110		
A56-3, checks combined			17.47±0.038	17.53±0.090

The data of greatest interest involve comparisons of the mean weight per root of the different root and hypocotyl segregates within the 55 plant random sample. There is a consistent increase in combining ability for weight per root in going from the yellow-root yellow-hypocotyl plants through the red-root red-hypocotyl plants to the white-root red-hypocotyl plants. Also, there is an increase in weight per root of the red-root red-hypocotyl segregates over the yellow-root yellow-hypocotyl segregates of the F_2 population. In all cases the increases are highly statistically significant. The increases in weight of root per plant range from 14 to 49 percent. In the commercial variety (A56-3) the white-root green-hypocotyl plants exceed in weight of root per plant the white-root red-hypocotyl plants by 11 percent. Hence, likewise in this material weight of root is definitely associated with hypocotyl color. The most logical explanation for this association is genetic linkage.

Another comparison of considerable interest involves the weight of roots of the white-root red hypocotyl segregates of A56-3 and the same phenotype of the 55 plant random sample X NBl CMS. The latter exceed the former by 49 percent.

From these studies the greatest increase in weight of root per plant attributable to selection is 16 percent, whereas that due to associations with root and hypocotyl color is 49 percent. This emphasizes the great value to breeding programs that could accrue from fundamental studies involving marker genes; that is, from genetic mapping of the sugarbeet chromosomes. This would apply not only to weight of root per plant, but also to the other economic characters such as percentage sucrose, percentage apparent purity, resistance to the attacks of organisms causing diseases, and chemical characters other than percentage sucrose.

Literature Cited

- (1) Keller, W. 1944. Inheritance of major color types in beets. Jour. Agr. Res. 52:27-35.
- (2) Lindhard, E. and A. Overton. 1919. Vererbung von roten und gelben farbenmerkmalen bei beta-wurden. Ztschr. Pflanzenzüchtung 7:1-18.
- (3) Powers, L., D. M. Schuster, and E. E. Remmenga. 1958. Estimation of the environmental variances and testing reliability of residual variances for weight per root in sugar beets. Jour. Amer. Soc. Sugar Beet Tech. 39(4):697-705.

The Interrelations of Weight of Roots Per Plot, Percentage Sucrose, and Milligrams of the Chemical Compound Per 100 Milliliters of Extract in Sugarbeets (*Beta vulgaris* L.) ^{1/}

This is a preliminary report on the chemical genetic studies involving the interrelations of weight of roots per plot, percentage sucrose and milligrams per 100 milliliters of extract of the chemical compound. One of the main interests in this compound is that it has been found to be associated with resistance to the attacks of *Cercospora beticola* Sacc. which produces the disease of sugarbeets commonly known as *Cercospora* leaf spot. For a review of the literature pertaining to the chemical aspects of resistance to *Cercospora* leaf spot in sugarbeets and for the chemical methods used in earlier studies see Harrison, Payne, and Gaskill^{2/}.

Some of the sugarbeet breeders have experienced considerable difficulty in combining the high degree of leaf spot resistance of such populations as US 201 with the high yield of roots per acre possessed by the commercial varieties. Therefore, it seemed desirable to study the interrelations of some of the more important agronomic characters: namely weight of roots per plot, percentage sucrose, and percentage apparent purity; and their interrelations with the chemical compound. The character percentage apparent purity is not included in this report.

The purposes of this report may be listed as follows:

(1) To determine the concentrations of the chemical compound in populations, some of which are known to differ in their resistance to the attacks of the organism causing *Cercospora* leaf spot.

(2) To determine the degrees of association, as regards both the environmental variability and the genetic variability, between weight of roots per plot and concentrations of the chemical compound, between percentage sucrose and concentrations of the chemical compound, and between weight of roots per plot and percentage sucrose.

(3) To evaluate the findings in relation to conducting further research and in relation to breeding sugarbeets.

^{1/} The chemical compound was isolated and identified by Mr. R. L. Gardner, a graduate student in the Chemistry Department of Colorado State University. The chemical description of the compound, methods and details are being prepared as a Ph.D. dissertation by Mr. Gardner.

^{2/} J. Am. Soc. Sugar Beet Technol. 11(6): 457-468. 1960.

Results

Range in concentrations of the chemical compound and association with resistance to *Cercospora* leaf spot

The mean concentrations of the chemical compound in populations are listed in table 1, together with the means for weight of roots per plot and means for percentage sucrose. Weight of roots per plot and percentage sucrose were not taken for *Beta maritima*. Also, when known, descriptions of the degree of leaf spot resistance are listed in table 1.

Table 1.--Population means for weight of roots per plot, percentage sucrose, and milligrams of the chemical compound per 100 milliliters of extract, chemical genetic studies, 1963.

Population and LSD	Leaf spot resistance ^{1/}	Weight	Sucrose	Chemical compound
		Kg	%	Mg/100ml
(52-305 CMS X 52-407)F ₁	Not known	9.74	16.14	17.76
US 201	Highly resistant	8.25	15.13	11.80
SP 581103-0 (<i>Beta maritima</i> L.)	Highly resistant			9.46
US 401 (4n)	Resistant	11.27	14.60	7.96
62-308 (2n)	Not known	10.68	15.32	7.72
SP 5822-0	Highly resistant	11.69	14.77	7.58
GWI-29 (Inbred)	Highly resistant	6.98	15.53	7.26
A56-3	Resistant	11.74	15.38	6.64
UI-112	Not known	10.76	15.15	6.53
GWI-81 (Inbred)	Highly susceptible	11.70	14.58	4.23
LSD at 5% level		0.679	0.399	1.772
LSD at 1% level		0.872	0.512	2.277

^{1/} The descriptions of the degree of leaf spot resistance are furnished by Mr. John O. Gaskill with the exception of that of GWI-81 (Inbred) which was furnished by Dr. R. K. Oldemeyer.

The genetic range in milligrams of the chemical compound per 100 milliliters of extract as represented by population means is from 4.23 to 17.76. The environmental range as represented by replications is from 3.76 to 17.99 (see table 2). Hence, the two are practically identical. The genetic range in degree of resistance is from highly susceptible to highly resistant. Those populations classified as highly resistant range in concentrations of the chemical compound from 7.26 to 11.80. Some of these mean concentrations are significantly different at the 1% level. Hence, the variation among those populations classified as highly resistant is not continuous. Likewise, this is true for the highly susceptible and the resistant as the difference between 4.23 and 6.64 is significant at the 1% level. Also, the variation is not continuous for US 201 and (52-305 CMS X 52-407)F₁, the former having a value of 11.80 and the latter a value of 17.76. The lack of continuous variation, for populations, in concentrations of the chemical compound is probably due to the small number (10) of populations studied. The range in variation, for replications, from 3.76 to 13.83 is continuous, but not from 13.83 to 17.99. Forty replications are involved.

The following conclusions can be drawn from the above findings:

(1) Further intensive and extensive studies are necessary to determine the degree of relation between concentrations of the chemical compound and resistance to the attacks of the organism causing Cercospora leaf spot.

(2) Also, further studies on the environmental and genetic relations between concentrations of the chemical compound and resistance are essential. The environmental variation should be expanded to include soil fertility levels. The genetic variation should be expanded to include more populations, both segregating (hybrids and otherwise) and nonsegregating (inbreds and F₁ hybrids). At least some, if not all the studies, should combine both the genetic and environmental variation in the same experiments.

Table 2.--Replication means for weight of roots per plot, percentage sucrose, and milligrams of the chemical compound per 100 milliliters of extract, chemical genetic studies, 1963.

Replication	Weight	Sucrose	Chemical compound
	Kg	%	Mg/100ml
25	9.97	15.9	17.99
22	9.92	15.8	13.83
21	10.09	15.8	13.37
29	9.77	15.7	13.10
28	9.59	15.5	12.77
10	10.44	14.7	12.64
23	9.81	16.4	12.47
19	10.02	15.1	12.35
24	9.46	16.4	12.12
34	10.68	15.3	12.05
35	11.23	15.3	10.91
36	11.41	14.6	10.35
38	10.96	15.6	10.19
33	10.44	15.8	10.16
14	9.62	15.7	9.78
37	10.24	15.0	9.68
27	10.99	15.0	9.40
31	11.27	15.2	9.18
20	9.39	16.4	9.05
26	10.89	14.9	8.55
18	10.47	15.9	8.49
12	10.51	14.6	8.07
13	9.76	14.9	8.07
32	11.11	14.9	7.99
17	9.06	15.4	7.27
11	9.83	15.3	7.06
30	10.35	15.1	6.51
39	11.39	15.3	6.10
15	9.19	15.9	5.51
5	10.28	13.6	5.50
40	9.68	15.5	5.49
9	9.83	15.1	4.89
1	11.04	14.6	4.62
6	10.77	14.2	4.59
2	11.44	14.2	4.45
7	11.22	14.6	4.25
16	8.87	14.6	4.10
3	11.11	14.2	3.95
4	11.02	14.7	3.80
8	9.41	14.3	3.76
LSD at 5% level	1.43	0.84	3.74
LSD at 1% level	1.84	1.08	4.82

The degrees of association between the chemical compound, weight of roots per plot and percentage sucrose

The degrees of association between the chemical compound, weight of roots per plot and percentage sucrose are shown by the correlation coefficients listed in table 3. All of these correlation coefficients are significantly different from zero and hence have some biological meaning. Weight of roots per plot and the chemical compound are negatively associated as is weight of roots per plot and percentage sucrose. Percentage sucrose and the chemical compound are rather highly associated. The association is positive. These findings hold for both the environmental and genetic variations.

Table 3. Correlation coefficients involving weight per plot, percentage sucrose, and milligrams of the chemical compound per 100 milliliters of extract, chemical genetic studies, 1963. ^{1/}

Characters Correlated	Correlation coefficients	
	Environmental	Genetic
Weight and the chemical compound	-0.141	-0.364
Sucrose and the chemical compound	0.602	0.703
Weight and sucrose	-0.429	-0.482

^{1/} The approximate value of r at the 5% level is 0.113 and of r at the 1% level is 0.148.

A comparison of the environmental and genetic correlation coefficients shows that they do not differ materially in magnitude as regards percentage sucrose and the chemical compound, and as regards weight of roots per plot and percentage sucrose. This could be taken as indicating (but not as proof) that the mechanism controlling the associations noted are the same in both cases.

To provide a basis for drawing conclusions and for planning further experiments a certain amount of speculation as to the reactions taking place to bring about the associations noted is justified. If the chemical compound acts in some capacity to regulate total nitrogen production in the beet plant, then, under the conditions of this experiment, the negative association between the chemical compound and weight of roots per plot would be expected. Also, the positive association between percentage sucrose and the chemical compound would be expected. Finally, weight of roots per plot and percentage sucrose would be expected to be negatively associated.

Discussion

The differences in concentrations of the chemical compound in populations classified as highly resistant to the attacks of Cercospora beticola, and the high concentrations of the chemical compound in the F₁ hybrid (52-305 CMS X 52-407), show the need for more extensive studies on the mechanism of disease resistance. Such studies should involve the relation between the polyphenolase enzyme, concentrations of the chemical compound, and disease resistance. One question of paramount importance is whether such populations as the F₁ hybrid (52-305 CMS X 52-407) possess the enzyme (polyphenolase) that brings about the oxidation of the chemical compound necessary for the production of substances toxic to Cercospora beticola? If not, would the incorporation of the enzyme in such populations produce materials extremely resistant to the attacks of Cercospora leaf spot? It becomes apparent that more information is needed on the mechanism of resistance to the attacks of Cercospora beticola and undoubtedly on the interrelations of the chemicals involved.

The interrelations found between the chemical compound and weight of roots per plot (negative association), the chemical compound and percentage sucrose (positive association), and weight of roots per plot and percentage sucrose (negative association) may have a very important bearing on yield and quality in sugarbeets. In this experiment the beets were grown after a crop of barley. In the fall of the year 20 pounds of nitrogen per acre were applied to induce more rapid decay of the barley stubble. In the spring another 100 pounds of N were added before planting the beets. This amount of N was believed to be that needed for

obtaining high yield and high sucrose content. If we were successful in accomplishing our purpose as regards the amount of nitrogenous fertilizer applied, then the concentration of the chemical compound, as influenced by both the genotype and the environment, has an important bearing on both yield and quality.

Finally, the degree of association attributable to genetic variability between the chemical compound and weight of roots per plot ($r = -0.364$) is not materially different from the degree of association attributable to genetic variability between percentage sucrose and weight of roots per plot (-0.482). The difficulties encountered in breeding for both high yield and high percentage sucrose are well known. It seems that it may be equally difficult to combine high yields with high concentrations of the chemical compound. Hence, the difficulty breeders have experienced in recombining high yield and high resistance to the attacks of the organism causing *Cercospora* leaf spot are not surprising, if resistance is dependent upon high concentrations of the chemical compound. The bright side of the picture is the high positive association between the chemical compound and percentage sucrose.

Further and more intensive investigations involving the disciplines of Chemistry, Pathology, and Genetics should have a very important application to the production by plant breeders of disease resistant, high quality and high yielding populations of beets.

Appendix

Two additional tables are appended for those who may wish to make a more detailed study of the data.

Table 4. Analysis of variance for weight of roots per plot, percentage sucrose, and milligrams of the chemical compound per 100 milliliters of extract, chemical genetic studies, 1960.

Source of variation and standard errors	Weight		Sucrose		Chemical compound	
	Degrees of freedom	Sums of squares	Variance	Sums of squares	Variance	Sums of squares
Replications	39	185.736882	4.762484	149.880862	3.843099	4297.107567
Populations	8	911.177000	113.897125	79.225556	9.903194	5017.081180
R X P	312	719.123556	2.304883	247.833888	0.794355	4899.475131
Total	359	1816.037438		476.945206		14213.663878
Standard error $\sqrt{}$			1.5182		0.8913	
						3.9628

$\sqrt{}$ These standard errors are for a single determination.

Table 5. F values for weight of roots per plot, percentage sucrose, and milligrams of the chemical compound per 100 milliliters of extract, chemical genetic studies, 1963.

Variation due to	F value			F value at	
	Weight	Sucrose	Chemical compound	5%	1%
Replications	2.07	4.84	7.02	1.98	2.60
Populations	49.42	12.47	39.94	1.45	1.69

Responses, as Measured by Yield and Quality, of Populations of Sugarbeets
to Dates of Harvest

In 1961, 1962, and 1963, studies were conducted to determine responses, as measured by yield and quality, of populations of sugarbeets to dates of harvest. The purposes of the study are as follows: (1) to determine whether the responses of some populations to the different dates of harvest are such as to make it economically feasible, from the standpoint of percentage sucrose and percentage apparent purity (quality), to start the harvest campaign from 2 to 4 weeks earlier than normally is the case, and (2) to determine levels at which concentrations of total nitrogen in the thin juice are adversely associated with percentage sucrose and percentage apparent purity.

Literature Review

The literature references are as follows. For methods used in making chemical determinations see Payne et al. (2) and for a review pertinent to quality see Rorabaugh and Norman (6), Carruthers and Oldfield (1), and Powers et al. (4). Payne, Powers, and Maag (3) have shown that populations of sugarbeets differ in the relative levels of total nitrogen, potassium, and sodium in the petioles as compared with levels of these same characters in the thin juice. It is well to keep in mind that the petioles are part of the tops of the sugarbeet plant; whereas, the thin juice is prepared from the roots. The interaction involving genotypes X materials analysed (petioles or thin juice) have shown that, at time of harvest, higher levels of the three chemicals occur in either the petioles or the thin juice, or in both. Conversely, at time of harvest, some genotypes have higher levels of these three chemical characters in the petioles associated with lower levels in the thin juice. The higher levels of these three chemicals in the thin juice have a decidedly adverse effect on percentage sucrose and percentage apparent purity, but such is not the case when the higher levels of these three chemicals are in the petioles, see Powers and Payne (5). This means that populations of sugarbeets can be bred having higher levels of total nitrogen in the petioles rather than in the thin juice with the accompanying benefits of higher yield without the reduction in percentage sucrose and percentage apparent purity.

Materials and Design of the Experiment

Over the 3-year period in which the experiment was conducted, the material consisted of 20 different populations in 1961, 13 in 1962, and 12 in 1963. Five of these populations were grown during each of the 3 years. Hence, 35 different populations were tested during the 3 years. Some data collected from an experiment conducted in 1956 are pertinent, and therefore a brief summary is presented, also.

The design of the experiment is a split plot with populations randomized within replications and dates of harvest randomized within blocks. Such a design leads to two estimates of error, designated here as errors A and B. Error variance A is used to evaluate significance of differences between dates of harvest. Error variance B is used to evaluate the significance of differences between populations and the first order interaction of populations X dates of harvest. For a more detailed presentation of the experimental design see "Sugarbeet Research 1962 Report", compiled by Sugarbeet Investigations, Crops Research Division, ARS, USDA.

Results

In a consideration of results the main effects of primary interest are populations, dates of harvest, and years. The interactions of primary interest are populations X dates and populations X dates of harvest X years. The analysis of variance for weight of roots per plot is given in table 1.

Table 1. Analysis of variance for weight of roots per plot of 5 populations for 3 dates of harvest during 1961, 1962, and 1963.

Variation due to:	DF	Mean square	F value		
			Obtained	Level	
				5%	1%
Replications	9	3.1759	1.98	1.92	2.50
Populations	4	403.4770	252.08	2.41	3.41
Dates	2	27.6370	6.90	3.55	6.01
Years	2	1385.4101	865.56	3.89	6.76
P X D	8	2.9014	1.81	1.98	2.60
P X D X Y	16	1.4888	----	----	----
Error A	18	4.0068			
Error B	252	1.6006			

A study of table 1 reveals that at least some of the differences between means for weight of roots per plot are significant at the 1% level for populations, for dates of harvest, and for years. In contrast the interactions of populations X dates and populations X dates of harvest X years are not significant at the 5% level.

The means for weight of roots per plot of populations for the three dates of harvest during 1961, 1962, and 1963 are listed in table 2. The fact that the interactions of populations X dates of harvest and populations X dates of harvest X years are relatively unimportant is of considerable interest. This indicates that as regards the populations and years sampled at the Agronomy Research Center farm, any one of the 3 years would have given reliable information regarding dates of harvest, populations, and the interaction of dates of harvest X populations. In other words the differences between the means of populations are comparable for each of the 3 dates of harvest and for any one of the 3 years. This finding is of particular importance in expediting research work involving different populations, as early harvesting of some experiments increases the amount of material that can be handled and also lowers the cost.

Table 2. Means for weight of roots per plot of populations for the three dates of harvest during 1961, 1962, and 1963. 1/

Population and average	Years and dates of harvest												Grand Average
	1961			Aver- age	1962			Aver- age	1963			Aver- age	
	9/15	10/1	10/15		9/15	10/1	10/15		9/15	10/1	10/15		
	Kg	Kg	Kg	Kg	Kg	Kg	Kg	Kg	Kg	Kg	Kg		
	52-305 CMS X 52-430 F ₁	5.69	5.56	5.86	5.70	9.58	11.24	10.76	10.53	7.02	7.08	7.01	
52-430 X 52-307 F ₁	8.81	8.70	8.91	8.81	11.30	12.05	12.45	11.93	15.18	14.27	16.50	15.32	12.02
52-430 X 54-565 F ₁	5.56	6.27	6.18	6.00	8.72	10.68	11.16	10.19	13.21	14.25	14.16	13.87	10.02
52-430 X 54-346 F ₁	6.88	6.92	6.70	6.83	9.28	10.52	10.16	9.96	13.08	14.23	13.94	13.75	10.19
A56-3 (check)	9.43	10.02	9.96	9.80	11.88	13.62	12.82	12.77	16.96	16.85	18.22	17.34	13.31
Average & Grand Average	7.27	7.49	7.52	7.43	10.15	11.62	11.47	11.08	13.09	13.34	13.97	13.46	10.66

1/ The least significant differences at the 5% level for populations within dates are as follows:
0.72 for 1961, 1.34 for 1962, and 1.46 for 1963.

For the years 1961 and 1962 the average weights of roots per plot at the bottom of table 2 do not differ materially for October 1 and October 15; whereas they do differ materially for 1963. The values are 7.49 compared with 7.52 for 1961, 11.62 compared with 11.47 for 1962, and 13.34 compared with 13.97 for 1963. Differences between the 3 years in moisture content and differences in the occurrence of temperatures below freezing could account for the interaction noted for dates of harvest and years. It is interesting to note, as shown previously, that populations X dates of harvest X years did not show any detectable interaction for weight of roots per plot. Hence, for most purposes (as regards the populations, dates of harvest and years sampled) one date of harvest for any one of the 3 years would have provided reliable information as to differences between populations as regards weight of roots per plot. Further research including more populations and years is necessary before broad generalizations are justified.

The analysis of variance for percentage sucrose of 5 populations for 3 dates of harvest over a period of 3 years is presented in table 3. The results of the analysis of variance for percentage sucrose are essentially the same as for weight of roots per plot, the exception being that the interaction of populations X dates of harvest X years are significant at the 5% level. This interaction, if supported by further research is economically important.

Table 3. Analysis of variance for percentage sucrose of 5 populations for 3 dates of harvest during 1961, 1962, and 1963.

Variation due to:	DF	Mean Square	F value		
			Obtained	Level	
				5%	1%
Replications	9	4.4057	11.33	1.92	2.50
Populations	4	42.6405	109.62	2.41	3.41
Dates	2	129.2491	332.26	3.55	6.01
Years	2	148.9611	382.93	3.89	6.76
P X D	8	0.6240	1.60	1.98	2.60
P X D X Y	16	0.7050	1.81	1.69	2.09
Error A	18	1.6004			
Error B	252	0.3890			

The interaction of populations X dates of harvest X years is most pronounced for populations 52-305 CMS X 52-430 F₁ and 52-430 X 52-307 F₁ (see table 4). The differences in percentage sucrose for these two populations for the 3 dates of harvest for the 3 years are 0.6, 0.4, and 0.7; 0.3, 0.0, and 0.4; and -0.3, -0.9, and -0.7, respectively. The differences are essentially the same for 1961 and 1962 and are in favor of 52-305 CMS X 52-430 F₁, whereas for 1963 they are in favor of 52-430 X 52-307 F₁. A t-test shows these differences to be statistically significant. The average differences of these two populations for the 3 years are 0.6, 0.2, and -0.6, respectively. These differences of 1.2 and 0.8 percent in sucrose for the first 2 years (1961 and 1962) compared with the last year (1963) are economically important.

Table 4. 1/ Means for percentage sucrose of populations for the three dates of harvest during 1961, 1962, and 1963.

Population and average	Years and dates of harvest												Grand Average		
	1961			1962			1963			Aver-					
	age			age			age			age					
	Kg	10/1	10/15	Kg	10/1	10/15	Kg	10/1	10/15	Kg	10/1	10/15		Kg	10/1
52-305 CMS X 52-430 F ₁	14.3	15.5	17.6	15.8	16.8	18.1	18.2	17.7	15.4	15.5	16.4	15.8	16.4	16.4	
52-430 X 52-307 F ₁	13.7	15.1	16.9	15.2	16.5	18.1	17.8	17.5	15.7	16.4	17.1	16.4	16.4		
52-430 X 54-565 F ₁	15.5	16.0	17.3	16.3	16.8	18.0	17.7	17.5	16.2	16.7	18.1	17.0	16.9		
52-430 X 54-346 F ₁	14.6	16.3	17.7	16.2	17.0	18.4	18.0	17.8	16.3	17.2	18.1	17.2	17.1		
A56-3 (check)	12.5	14.2	15.2	14.0	15.9	17.3	17.3	16.8	14.5	15.1	16.0	15.2	15.3		
Average & Grand Average	14.1	15.4	16.9	15.5	16.6	18.0	17.8	17.5	15.6	16.2	17.1	16.3	16.4		

1/ The least significant differences at the 5% level for populations within dates is 0.6 for each of the 3 years (1961, 1962, and 1963).

Another interaction of interest is dates of harvest X years. For the years 1961 and 1963 there is a consistent increase from September 15 through October 1 to October 15. However, for 1962 there is no material difference in percentage sucrose for the October 1 and October 15 dates of harvest. This is true for all populations as well as for the average of all populations. This might be interpreted as furnishing evidence that the maximum percentage sucrose obtainable is 18.0. This is supported by the October 15, 1963 data for populations 52-430 X 54-565 F₁ and 52-430 X 54-346 F₁, as for this date of harvest these two populations reached a sucrose content of 18.1 percent. If we were to accept this interpretation, a further logical conclusion would be that A56-3 has a maximum sucrose percent of 17.3. However, such is not correct because commercial fields of this population have produced more than 18.0 percent sucrose. Also, A54-1 of which A56-3 is a direct seed increase, under experimental conditions has produced 18.4 percent sucrose (see Powers et al. 4). Therefore, it seems that these data do not indicate the maximum percent of sucrose that can be obtained in populations of sugarbeets.

Of interest is the comparisons in percentage sucrose of populations 52-430 X 54-565 F₁ harvested on September 15 and A56-3 harvested on October 15, approximately one month later. The comparisons are 15.5 and 15.2 for 1961, 16.8 and 17.3 for 1962, and 16.2 and 16.0 for 1963. These data show that there is no difference between the sucrose content of 52-430 X 54-565 F₁ and A56-3 when the former is harvested one month earlier than the latter. In 1961 the corresponding purities were 94.7 for 52-430 X 54-565 F₁ harvested on September 15 and 92.9 for A56-3 harvested on October 15. In this study dates of harvest had no appreciable effect on either percentage apparent purity nor on milligrams of total nitrogen per 100 milliliters of thin juice. That is the different dates of harvest did not differ materially as regards percentage apparent purity or concentration of total nitrogen in the thin juice. Population 52-430 X 54-565 F₁ averaged 49 percent lower in weight of roots per plot than A56-3 harvested a month later. This value was derived from the averages of the 3-year period. As shown above, the hybrid equaled A56-3 in percentage sucrose when harvested a month earlier and excelled it in percentage apparent purity. It is clear that populations of sugarbeets can be bred which will have satisfactory percentages of sucrose and percentages of apparent purity when harvested a month earlier than the commercial varieties. However, it is equally clear that if these same populations were grown for another month there would be an increase in both yield of roots per plot and percentage sucrose. In other words satisfactory processing quality can be bred into hybrid populations produced for early harvest, but it will result in lower yields of sugar per acre.

In connection with the dates of harvest studies conducted in 1961 an attempt was made to determine the association between concentrations of total nitrogen in the petioles and concentrations of total nitrogen in the thin juice with weight of roots per plot, percentage sucrose, and percentage apparent purity. The data are presented in table 5.

Table 5. Means of weight of roots per plot, percentage sucrose, and percentage apparent purity and levels of concentration of total nitrogen in the petioles and in the thin juice.

Population	Weight	Sucrose	Purity	Total nitrogen	
				Petioles	Thin juice
	Kg	%	%	Mg/100gm	Mg/100ml
52-305 CMS X					
54-458 F ₁	5.257	14.8	91.8	1321.0	64.9
52-430 X					
52-408 F ₁	7.353	15.5	94.7	1431.8	44.8
A56-3	7.843	14.0	93.1	1531.2	54.4
LSD at 5%	0.414	0.34	0.80	77.8	3.9
LSD at 1%	0.545	0.45	1.06	102.6	5.1

The comparison between the means of the F₁ hybrid 52-305 CMS X 54-458 and the F₁ hybrid 52-430 X 52-408 show that an increase of total nitrogen in the petioles and a decrease of total nitrogen in the thin juice are accompanied by an increase in weight of roots per plot, an increase in percentage sucrose and an increase in percentage apparent purity. The comparison involving the F₁ hybrid 52-430 X 52-408 with A56-3 shows that a further increase of total nitrogen in the petioles and a further increase of total nitrogen in the thin juice are accompanied by a further increase in weight of roots per plot and by a decided decrease in percentage sucrose and in percentage apparent purity. From these comparisons it is clear that increases of total nitrogen in the petioles rather than in the thin juice can result in an increase in all 3 of the important agronomic characters; weight of roots per plot, percentage sucrose, and percentage apparent purity. They further show that total nitrogen in the thin juice does not have an adverse association with weight of roots per plot; but is adversely associated with percentage sucrose and percentage apparent purity. Hence, weight of roots per plot, percentage sucrose, and percentage apparent purity, in some populations, are favorably associated with total nitrogen in the petioles; but not with total nitrogen in the thin juice. Therefore, the sugarbeet breeder should be able to increase these three desirable agronomic characters by breeding genotypes having high levels of total nitrogen in the petioles at time of harvest. These results indicate that higher levels of total nitrogen in the petioles are conducive to higher yield of roots but are not conducive to lower percentages of sucrose nor

lower percentages of apparent purity. Conversely, higher levels of total nitrogen in the thin juice are not necessarily conducive to higher yields of roots; but are conducive to lower percentage sucrose and lower percentage apparent purity. Hence, it seems as though the plant breeder can improve quality by genetically controlling the location, at time of harvest, of higher levels of total nitrogen; that is, by breeding those genotypes having higher levels of this chemical in the petioles instead of in the thin juice.

Data collected in 1956 and 1961 have considerable bearing on the associations between concentrations of total nitrogen in the thin juice and percentage sucrose and percentage apparent purity. The data are presented in table 6. There does not seem to be much reduction in percentage sucrose up to and including concentrations of 25.7 milligrams per 100 milliliters of thin juice equated to a refractometer reading of 10. However, at concentrations of 38.6 milligrams of total nitrogen per 100 milliliters of thin juice there is a decided reduction in percentage sucrose. The loss in percentage sucrose in going from a concentration of 38.6 milligrams of total nitrogen per 100 milliliters of thin juice to a concentration of 54.4 is 3.1 percent for the commercial check. Considering the association between concentrations of total nitrogen in the thin juice and percentage apparent purity, it is clear that an increase in concentration of total nitrogen in the thin juice is accompanied by a consistent decrease in percentage apparent purity. In fact, 95 percent of the variability in percentage apparent purity is accounted for by covariance, that is, by the variability of concentration of total nitrogen in the thin juice. In going from a concentration of 8.8 milligrams of total nitrogen in the thin juice to a concentration of 64.9 there is a reduction of 6 percent in percentage apparent purity. An increase in impurities (lower purity) has a decidedly adverse effect on processing sugarbeets (see Rorabaugh and Norman, 6) and (see Carruthers and Oldfield, 1). It is much more difficult to crystallize the sugar from the beet sirup when percentage apparent purity is low.

Table 6. Percentage sucrose, concentrations of total nitrogen in the thin juice, and percentage apparent purity for fertilizer treatments, and populations in 1956, and for populations in 1961.

Year, treatment and population	Character		
	Sucrose	Nitrogen	Purity
	%	Mg/100ml	%
1956			
Non-fertilized			
50-406 X 52-307 F ₁	18.3	8.8	97.8
50-406BB	18.0	10.8	97.5
A54-1	18.4	12.6	97.0
Fertilized			
50-406 X 52-307 F ₁	18.5	17.8	95.5
50-406BB	18.1	25.7	95.3
A54-1 (check)	17.1	38.6	94.2
LSD at 5% level	0.3	3.2	0.4
1961			
52-430 X 54-565 F ₁	16.3	41.6	95.6
52-430 X 52-408 F ₁	15.5	44.7	94.7
A56-3 (check)	14.0	54.4	93.1
52-305 CMS X 54-458 F ₁	14.8	64.9	91.8
LSD at 5% level	0.3	3.9	0.6

From these comparisons it is clear that increases of total nitrogen in the petioles rather than in the thin juice can result in an increase in all 3 of the important agronomic characters, weight of roots per plot, percentage sucrose, and percentage apparent purity. Further, these data show that high concentrations of total nitrogen in the thin juice is not adversely associated with weight of roots per plot but is adversely associated with percentage sucrose and percentage apparent purity.

Summary

The data showed that populations of sugarbeets can be bred that will have as high a percentage of sucrose and as high a percentage of apparent purity when harvested a month earlier as do the presently grown commercial varieties harvested a month later. However, these same populations, if allowed to grow a month longer (harvested at the regular date of harvest), will show a corresponding increase in yield of roots and percentage sucrose but will not show an increase in percentage apparent purity. Hence, the early harvest as regards quality is economically feasible.

It was found that levels of total nitrogen beyond 25.7 milligrams per 100 milliliters of thin juice equated to a refractometer reading of 10 is associated with a reduction in percentage sucrose. The loss in percentage sucrose in going from a concentration of 38.6 milligrams of total nitrogen per 100 milliliters of thin juice to a concentration of 54.4 is 3.1 percent. Considering the association between concentrations of total nitrogen in the thin juice and percentage apparent purity it was found that an increase in total nitrogen in the thin juice is accompanied by a consistent decrease in percentage apparent purity. In going from a concentration of 8.8 milligrams of total nitrogen in the thin juice to a concentration of 64.9 there is a reduction of 6 percent in percentage apparent purity.

Further, it was found that higher levels of total nitrogen in the petioles is conducive to higher yield of roots and are not associated with lower percentage sucrose or lower percentage apparent purity. Conversely, higher levels of total nitrogen in the thin juice are not necessarily conducive to higher yields of roots, but are associated with lower percentage sucrose and lower percentage apparent purity.

Literature Cited

- (1) Carruthers, A. and J. F. T. Oldfield. 1961. Methods for the assessment of beet quality. Intern. Sugar J. 63:72-74, 103-105, 137-139.
- (2) Payne, Merle G., LeRoy Powers and E. E. Remmenga. 1961. Some chemical genetic studies pertaining to quality in sugar beets (Beta vulgaris L.). J. Am. Soc. Sugar Beet Technol. 11(7):610-628.
- (3) Payne, Merle G., LeRoy Powers and Grace W. Maag. In press. Levels of total nitrogen, potassium, and sodium in petioles and thin juice of sugarbeets.
- (4) Powers, LeRoy, D. W. Robertson, Robert S. Whitney and Willard R. Schmehl. 1958. Population genetic studies with sugar beets (Beta vulgaris L.) at different levels of soil fertility. J. Am. Soc. Sugar Beet Technol 9(8): 637-676.
- (5) Powers, LeRoy and Merle G. Payne. In press. Association of levels of total nitrogen, potassium, and sodium in petioles and in thin juice with weight of roots per plot, percentage sucrose, and percentage apparent purity.
- (6) Rorabaugh, Guy and Lloyd W. Norman. 1956. The effects of various impurities on the crystallization of sucrose. J. Am. Soc. Sugar Beet Technol. 9(3):238-252.

P A R T VII

POLYPLOIDY IN RELATION TO ROOT YIELD,
SUCROSE PERCENTAGE, AND DISEASE RESISTANCE

- - - - -

INTERSPECIFIC HYBRIDIZATION
and
STUDIES ON TETRAPLOIDY

Foundation Project 11

Helen Savitsky

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POLYPLOIDY IN SUGARBEETS

THE RESULTS OF TRIENNIAL STUDY OF EFFECT OF HYBRIDIZATION AND SELECTION FOR CURLY TOP AND LEAF SPOT RESISTANCE IN TETRAPLOID SUGARBEET STOCK.

V. F. Savitsky, Helen Savitsky, Albert M. Murphy.

During 3 years the same 29 tetraploid sugarbeet populations were studied for curly top and leaf spot resistance in Logan, Utah, and in Fort Collins, Colorado. Some diploid varieties in which the grade of resistance to curly top and leaf spot was known were included for methodological purposes in the experiment.

Experiment dealt with the elucidation of the following statements:

- a/ The effect of chromosome doubling on the grade of leaf spot resistance in sugarbeets.
- b/ The possibility of improvement of the grade of resistance to both curly top and to leaf spot by selection in the tetraploid lines originated from the same tetraploid population.
- c/ The possibility of synthesis of 2 resistances - the resistance to curly top and the resistance to leaf spot in one tetraploid hybrid population, derived from hybridization of 2 tetraploid populations which originated from 2 diploid populations, each being resistant to one disease only (curly top or leaf spot).

MATERIALS AND METHOD

The following tetraploid lines were studied: a) eight lines selected in tetraploid US 401 for curly top resistance in Salt Lake City, Utah; b) seven lines selected in tetraploid US 401 for leaf spot resistance in Fort Collins, Colorado; c) seven lines selected in tetraploid US 401 for vigor and dry matter; and d) six tetraploid F₄ hybrids derived from crosses of a monogerm line with medium grade of curly top resistance to tetraploid US 401.

In the experiment were included as a check diploid US 401, the original tetraploid population of US 401, the highly leaf spot resistant multigerm variety US 201, and the highly leaf spot resistant monogerm diploid inbred S-23, US 35/2, and a European variety susceptible to both curly top and leaf spot.

Tests for leaf spot resistance were performed by J.A.Elder and J.O.Gaskill in Fort Collins, Colorado. Plantings were made in 2-row plot in a randomized block design in 3 replications. Artificial inoculation and frequent sprinkling were employed to promote development of leaf spot. The August readings were made at the approximate peak of the epidemic by J. A. Elder.

Test for curly top resistance was performed by A. M. Murphy at Thatcher, Utah. Tetraploid lines were randomized in single-row plots (50 feet long). The curly top exposure was increased on the test populations by planting susceptible beets (Klein) about 2 months earlier than the test planting. Virulent strains of curly top virus were introduced by transplanting diseased beets selected the previous year. Reading of curly top severity was made by V.F. Savitsky in the middle of September. Each plot was given a general evaluation. Readings were made also for each individual plant in all plots.

Mean squares, degrees of freedom in analysis of variance for leaf spot resistance are shown in the table 1, and for curly top resistance in the table 2. Analysis of variance for leaf spot resistance indicated significant differences between populations, while the differences between years and replications were not proved statistically. Analysis of variance for curly top resistance showed significant differences between populations and between the grades of curly top severity in different years.

Differences between populations may be considered significant with the evaluation for curly top resistance equal to 0.93, and for leaf spot resistance to 0.86; i.e., that statistically proved differences in resistance to both diseases were almost identical. (Tables 3-7, inclusive.)

EXPERIMENTAL RESULTS

Leaf spot resistance and curly top resistance in tetraploid lines selected in the population of US 401 for leaf spot resistance.

Seven lines derived from 7 plants selected for leaf spot resistance in the tetraploid population US 401 in Fort Collins, Colorado, appeared very uniform in the grade of leaf spot resistance and differed in the grade of resistance to curly top (table 3).

The average evaluation of resistance to leaf spot in 7 lines during 3 years was a little higher than the evaluation of resistance in the original tetraploid population of US 401, but this difference was insignificant. The average evaluation of leaf spot resistance equaled 3.5 in 7 lines studied, the average evaluation of the original diploid population equaled 3.61 and of the original tetraploid population, 3.89. The line most susceptible to leaf spot, of the 7 lines studied, had evaluation for resistance 3.7. In this way selection for leaf spot resistance eliminated in the population US 401 genotypes which were the most susceptible to leaf spot.

All 7 tetraploid lines showed significantly higher resistance to curly top than the diploid population of US 401. Their average evaluation for curly top resistance equaled 5.40, while the resistance to curly top in the diploid US 401 equaled only 8.10. (Table 7.)

The average for 3 years' evaluation of 7 lines in curly top resistance did not differ significantly from the average evaluation of resistance in the original tetraploid population of US 401.

The grade of curly top resistance equaled 3.83 for the most resistant of the 7 lines, and the line most susceptible to curly top had the evaluation 6.67. This susceptible line differed significantly in curly top resistance from the original tetraploid population of US 401.

Leaf spot and curly top resistance in tetraploid lines selected in US 401 for curly top resistance.

Eight tetraploid lines, the progenies of 8 individual plants selected for curly top resistance in the tetraploid population of US 401, were studied in this experiment. The average triennial evaluation of curly top resistance in these 8 lines equaled 3.83 (table 4). This average grade of resistance differs significantly from the grade of curly top resistance in the original diploid variety US 401 and in the original tetraploid population of US 401, and also from the average resistance of the 7 lines selected for leaf spot resistance (table 4 and 7). Individual lines in the group of 8 lines studied differed significantly among themselves in resistance to curly top. Evaluation of curly top resistance in different lines varied from 2.67 to 4.50, while the variation in curly top resistance in 7 lines selected for leaf spot resistance was 3.83 to 6.67. Selection for curly top resistance was effective. Effectiveness was partly due to the mortality of all plants susceptible to curly top, because the plants which survived until spring and were transplanted into the field perished before flowering if they were infected by curly top. Selection pressure for curly top resistance was almost maximal.

The average evaluation of 8 lines studied in resistance to leaf spot equaled 3.60. These lines almost did not differ in the grade of resistance from the diploid and tetraploid original populations of US 401.

Leaf spot and curly top resistance in tetraploid lines selected in US 401 for vigor and dry matter.

Seven tetraploid lines, the progenies of the individual plants selected for vigor and dry matter in the tetraploid population of US 401, were studied during 3 years (tables 5 and 7). Selection for vigor was conducted under conditions where the beets were not infected by curly top or leaf spot.

Selection for vigor did not show negative influence on resistance to curly top, nor on resistance to leaf spot in these 7 lines.

The average leaf spot resistance for the 7 lines equaled 3.47, while in the diploid population of US 401 it was 3.61, and in the tetraploid population of US 401 it was 3.89.

The average evaluation of 7 lines for curly top resistance equaled 5.17 and of the tetraploid original population of US 401 equaled 4.83. Difference of 0.34 in resistance between the 7 lines and the tetraploid US 401 is much lower than the value of msd (0.93) for curly top resistance (tables 5 and 7).

The group of 7 lines was significantly lower in curly top resistance than the group of 8 lines selected for resistance to curly top.

Among 7 lines selected for vigor, evaluation for resistance to curly top in the most resistant line was only 4.50. This value of curly top resistance corresponded to the grade of the lowest in curly top resistance line among the group of 8 lines, the ancestors of which were selected for curly top resistance.

Combination of curly top and leaf spot resistance in one tetraploid population.

The resistance to curly top as well as the resistance to leaf spot are metrical traits. A genetic study indicated that their inheritance is controlled by the polygenic system. Breeding for resistance to any one disease was usually done independently in breeding for another one. Therefore, in the polymorphism of Beta vulgaris, 2 complexes of genes were established: a complex of genes responsible for leaf spot resistance and a corresponding complex of genes for curly top resistance. These genic complexes were maintained in different populations.

Breeding for the optimal grade of resistance in each complex proved to be much more easier than the breeding for the optimal grade of resistance to both diseases in one population. Combination of such genic complexes in one diploid population is the simplest in F_1 hybrids. In some instances such hybrids may be valuable to some extent because as a leaf spot resistance, so also resistance to curly top shows phenotypical partial dominance. However, the F_1 hybrids usually do not exhibit such high performance in resistance to both diseases as the original parental populations to one disease. Later generations of such F_1 hybrids cannot be used directly for practical purposes if they have not been improved by special breeding methods during several generations. The necessity of breeding in the diploid hybrids is stipulated by the established in the F_2 - F_4 generations equilibrium of genes. This equilibrium is connected with the insufficient frequency of genes providing for the uniformity and desirable level of resistance to both diseases in the F_3 - F_4 hybrid generations. To obtain the desirable result, breeding for resistance to both diseases should be based on the individual method of selection which is connected with the admission of more, or less close inbreeding. This method will lead to automatical destruction of heterozygotes, not only heterozygotes inherent in F_1 hybrids, but also those heterozygotes which carried the original varieties. Therefore, if the resistance to curly top, or to leaf spot in the original varieties depended even partly on heterozygotes, combination of both resistances by selection and inbreeding requires formation of a new genic system for each character, a structure which was absent in the parental varieties. Only a large scale of breeding during several generations will make possible

the combination of resistances to both diseases in one diploid population. In the later hybrid generations, and even in F_1 diploid hybrids between 2 varieties heterozygous in some genes controlling the resistance, some plants will always be deprived of these necessary genes. In the tetraploid F_1 hybrids, and in the later hybrid generations, the percent of plants deprived of such necessary genes will always be much lower. Effects following this genetic equilibrium in F_1 and later hybrid generations will lead to big differences in resistance between diploid and tetraploid populations, nevertheless the resistance in these populations will be based on the same gene pool and the expression of resistance in their F_1 hybrids may be phenotypically close.

Differences in curly top and leaf spot resistance between diploid and tetraploid hybrids are caused by several genetic conditions. The main difference is that the tetraploid F_1 hybrids receive a diploid instead of a haploid set of chromosomes and genes from each parent. Segregation in F_2 tetraploid hybrids is very slow, a new proportion of hetero- and homozygotes is established, and many new types of heterozygotes are formed, everyone of which carries at least one dominant gene. The recessive characters segregate according to another ratio, equilibrium in tetraploid populations is established later and at another combination of hetero- and homozygotes. Different genetic structure of diploid and tetraploid populations may lead to different expression of curly top and leaf spot resistance in F_2 - F_4 generation of diploid and tetraploid hybrids, even if they ^{were} derived from the same parental varieties. Because of different genetic structure tetraploids offer a new mode of combination of resistances to 2 diseases in one population, a mode which is impossible in diploids. For verification of this hypothesis the F_2 - F_4 tetraploid hybrids, derived from hybridization of 2 tetraploid varieties, each resistant to one disease only, should be tested for the resistance to both diseases. Such 6 tetraploid F_4 hybrids were tested for resistance to 2 diseases. The 6 F_4 hybrids were isolated in the F_2 tetraploid hybrids, derived from crosses of monogerm self-sterile stock (with a medium grade of resistance to curly top and susceptible to leaf spot) with leaf spot resistant US 401. The F_2 plants and their progenies grew in Salt Lake City under conditions free of curly top or leaf spot infection.

The resistance to leaf spot, average for 3 years, equaled in these 6 hybrids 3.5828; i.e. the grade of resistance was the same as in the diploid variety US 401, the grade of resistance in which equaled 3.61 (table 6). All 6 lines exhibited almost the same grade of resistance to leaf spot; variation in the grade of resistance in separate lines was 3.44 to 3.78.

The grade of curly top resistance, average for 3 years, equaled in the 6 hybrids 2.89. The hybrids exceeded in curly top resistance the diploid and tetraploid population US 401 and also all tetraploid lines isolated in the population US 401 which were not selected for curly top resistance (table 7). Some lines isolated in the tetraploid population of

US 401 and selected for curly top resistance received approximately the same high evaluation in curly top resistance as the 6 hybrid lines studied (table 4 and 6).

Only in tetraploid hybrids we succeeded to combine in many lines the resistance to curly top and to leaf spot with the index of resistance 0.81 (table 6 and 7). In these hybrids resistance to both diseases was close to the grade of resistance of each disease which had 2 separate diploid parents.

CONCLUSION

The triennial study of tetraploid lines and hybrids made possible to draw the following conclusions:

- 1/ The tetraploid lines isolated in the tetraploid population US 401 showed mostly the same grade of leaf spot resistance than the diploid population of US 401.
- 2/ At the same time, the majority of these tetraploid lines exceeded the curly top resistance of the diploid variety US 401.
- 3/ Tetraploid lines isolated in the same population differed significantly among themselves in the grade of curly top (S-62-11 and S-62-14) and leaf spot resistance (S-62-11 and S-62-9).
- 4/ Selection for leaf spot and for curly top resistance is effective in tetraploid sugarbeets. Selection for resistance to either disease eliminated the lines susceptible to this disease and decreased the amplitude of variation in resistance to the selected disease. Selection for other characters (for instance for vigor) did not significantly decrease the resistance to curly top, or to leaf spot in the lines studied.
- 5/ Because the majority of lines, isolated in the tetraploid population of US 401, showed higher resistance to curly top than the diploid US 401, the resistance to leaf spot was combined in these lines with a higher grade of curly top resistance than it was in the diploid US 401. Individual tetraploid lines selected in the tetraploid population of US 401 showed in the triennial tests still higher grades of resistance to leaf spot and curly top than the original tetraploid population of US 401.
- 6/ The best combination of both diseases did not result from selection within a population. The combination giving the highest degree of resistance to leaf spot and curly top was more often obtained in the tetraploid lines selected in the F_2 generation of hybrids derived from hybridization of 2 different tetraploid populations, every one of which was resistant to only one disease.

7/ A method of combining 2 desirable genomes from different autotetraploids in one tetraploid population is an important breeding method for association of polygenetic traits, if the desirable grade of both traits is manifested in the F_1 generation.

We express our appreciation to John O. Gaskill and J.A. Elder for conducting experiments for leaf spot resistance at Fort Collins, Colorado.

Table 1 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for leaf spot resistance in diploid and tetraploid stocks of sugarbeets in Fort Collins, Colorado in 1962, 1963 and 1964.

	Degree of freedom	Sum of squares	Mean square	Variance Ratio	F	
					005	001
Total sum of squares	296	250.4500				
Reps	2	4.4170	2.2085	0.7582	3.04	4.71
Years	2	3.0357	1.5179	0.5211	3.04	4.71
Populations	32	167.2556	5.2267	17.9427	1.51	1.77
Error	260	75.7417	0.2913	-	-	-

Table 2 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for curly top resistance in diploid and tetraploid stocks of sugarbeets at Logan, Utah in 1962, 1963 and 1964.

	Degree of freedom	Sum of square	Mean Square	Variance Ratio	F	
					005	001
Total sum of squares	98	328.6700				
Years	2	6.6836	3.3418	10.2352	3.15	4.98
Populations	32	301.0867	9.4090	28.8178	1.65	2.03
Error	64	20.8997	0.3265	-	-	-

Table 3 ... Evaluation of curly top and leaf spot resistance in tetraploid lines selected for leaf spot resistance.

C o d e W			Leaf spot resistance				Curly top resistance				Index
1962	1963	1964	1962	1963	1964	Mean	1962	1963	1964	Mean	ct ls
S-62-1	S-62-23	S-64-14	3.00	4.00	3.67	3.56	7.0	7.0	6.0	6.67	1.88
S-62-2	S-63-24	S-64-4	3.00	4.00	4.00	3.67	5.0	4.0	4.5	4.50	1.23
S-62-3	S-63-25	S-64-5	2.50	4.00	3.67	3.39	3.0	4.0	4.5	3.83	1.13
S-62-4	S-63-14	S-64-3	3.00	3.50	3.67	3.39	7.0	6.0	6.5	6.50	1.92
S-62-5	S-63-16	S-64-11	3.50	3.83	3.50	3.61	5.0	5.0	4.5	4.83	1.34
S-62-6	S-63-15	S-64-20	3.33	4.00	3.67	3.67	5.5	5.0	4.0	4.83	1.32
S-62-7	S-63-29	S-64-8	2.83	3.83	3.00	3.22	7.0	7.0	6.0	6.67	2.07
Mean			3.02	3.88	3.60	3.50	5.64	5.43	5.14	5.40	1.54
2n US 401			3.00	4.00	3.83	3.61	8.5	7.8	8.0	8.10	2.24
4n US 401			3.67	4.00	4.00	3.89	5.0	4.0	5.5	4.83	1.24
2n US 35/3			-	-	-	-	2.0	2.0	3.0	2.33	-
2n Klein			5.00	6.67	6.17	5.95	9.5	9.0	8.5	9.00	1.51
2N US 201			1.50	2.17	1.17	1.61	-	-	7.7	7.70	4.78
2n S-23-m ²			1.00	1.17	0.50	0.89	9.5	9.0	8.0	8.83	9.92
msd						0.86				0.93	
lsd						1.14				1.24	

Table 4 ... Evaluation of curly top and leaf spot resistance in tetraploid lines selected for curly top resistance.

C o d e W			Leaf spot resistance				Curly top resistance				Index
1962	1963	1964	1962	1963	1964	Mean	1962	1963	1964	Mean	ct ls
S-62-22	S-63-1	S-64-15	3.00	3.67	3.33	3.33	4.0	3.0	2.5	3.17	0.95
S-62-23	S-63-2	S-64-16	3.50	3.67	4.00	3.72	4.0	3.0	4.5	3.83	1.03
S-62-24	S-63-3	S-64-19	3.67	4.17	4.33	4.06	5.0	4.0	3.0	4.00	0.99
S-62-25	S-63-22	S-64-13	3.83	4.00	4.00	3.93	5.0	4.0	3.5	4.17	1.06
S-62-26	S-63-4	S-64-17	3.33	3.67	3.33	3.44	3.0	3.0	2.0	2.67	0.77
S-62-27	S-63-5	S-64-18	2.50	3.67	3.17	3.11	5.0	5.0	3.5	4.50	1.45
S-62-28	S-63-6	S-64-27	3.17	4.17	3.50	3.61	4.0	5.0	3.5	4.17	1.16
S-62-29	S-63-7	S-64-12	2.83	4.00	3.83	3.55	5.0	4.0	3.5	4.17	1.17
Mean			3.23	3.87	3.69	3.60	4.37	3.87	3.25	3.83	1.07
2n US 401			3.00	4.00	3.83	3.61	8.5	7.8	8.0	8.10	2.24
4n US 401		3.67	3.67	4.00	4.00	3.89	5.0	4.0	5.5	4.83	1.24
2n US 35/3			-	-	-	-	2.0	2.0	3.0	2.33	-
2n Klein			5.00	6.67	6.17	5.95	9.5	9.0	8.5	9.00	1.51
2n US 201			1.50	2.17	1.17	1.61	-	-	7.7	7.70	4.78
2n S-23-m ²			1.00	1.17	0.50	0.89	9.5	9.0	8.0	8.83	9.92
msd						0.86				0.93	
lsd						1.14				1.24	

Table 5 ... Evaluation of curly top and leaf spot resistance in tetraploid lines selected for vigor and dry matter in a tetraploid population of US 401.

C o d e W			Leaf spot resistance				Curly top resistance				Index
1962	1963	1964	1962	1963	1964	Mean	1962	1963	1964	Mean	ct ls
S-62-8	S-63-26	S-64-10	3.00	4.50	3.83	3.77	6.0	6.0	6.0	6.0	1.59
S-62-9	S-63-28	S-64-9	3.50	4.50	3.50	3.83	5.5	5.0	5.0	5.17	1.35
S-62-10	S-63-27	S-64-6	3.00	4.17	2.83	3.33	5.0	5.0	4.0	4.67	1.40
S-62-11	S-63-17	S-64-2	2.33	3.50	3.00	2.94	5.0	4.0	4.5	4.50	1.53
S-62-12	S-63-18	S-64-28	3.17	4.00	3.00	3.39	6.0	4.0	3.5	4.50	1.33
S-62-13	S-63-19	S-64-21	3.33	4.00	3.83	3.72	5.0	5.0	4.0	4.67	1.29
S-62-14	S-63-20	S-64-1	2.50	4.00	3.50	3.33	7.0	7.0	6.0	6.67	2.00
Mean			2.98	4.10	3.36	3.47	5.64	5.14	4.71	5.17	1.49
2n US 401			3.00	4.00	3.83	3.61	8.5	7.8	8.0	8.10	2.24
4n US 401			3.67	4.00	4.00	3.89	5.0	4.0	5.5	4.83	1.24
2n US 35/3			-	-	-	-	2.0	2.0	3.0	2.33	-
2n Klein			5.00	6.67	6.17	5.95	9.5	9.0	8.5	9.00	1.51
2n US 201			1.50	2.17	1.17	1.61	-	-	7.7	7.70	4.78
2n S-23-m ²			1.00	1.17	0.50	0.89	9.5	9.0	8.0	8.83	9.92
msd						0.86				0.93	
lsd						1.143				1.24	

Table 6 ... Evaluation of curly top and leaf spot resistance in tetraploid F₄ hybrids derived from crosses of tetraploid monogerm self-sterile strain to tetraploid US 401.

C o d e W			Leaf spot resistance				Curly top resistance				Index
1962	1963	1964	1962	1963	1964	Mean	1962	1963	1964	Mean	$\frac{ct}{ls}$
S-62-15	S-63-8	S-64-29	3.17	3.33	3.83	3.44	2.5	3.5	2.5	2.83	0.82
S-62-16	S-63-9	S-64-26	3.33	4.00	3.33	3.55	2.0	2.0	2.0	2.00	0.56
S-62-17	S-63-11	S-64-24	3.83	4.00	3.50	3.78	2.5	3.0	3.0	2.83	0.75
S-62-18	S-63-10	S-64-25	3.50	4.00	3.67	3.72	4.0	4.0	3.0	3.67	0.99
S-62-19	S-63-12	S-64-23	3.33	4.00	3.33	3.55	3.0	3.0	4.0	3.33	0.94
S-62-20	S-63-13	S-64-22	3.17	4.00	3.17	3.45	3.0	3.0	2.0	2.67	0.78
Mean			3.39	3.89	3.47	3.58	2.83	3.08	2.75	2.89	0.81
2n US 401			3.00	4.00	3.83	3.61	8.5	7.8	8.0	8.10	2.24
4n US 401			3.67	4.00	4.00	3.89	5.0	4.0	5.5	4.83	1.24
2n US 35/2			-	-	-	-	2.0	2.0	3.0	2.33	
2n Klein			5.00	6.67	6.17	5.95	9.5	9.0	8.5	9.00	1.51
2n US 201			1.50	2.17	1.17	1.61	-	-	7.7	7.7	4.78
2n S-23-m ²			1.00	1.17	0.50	0.89	9.5	9.0	8.0	8.83	9.92
msd						0.86				0.93	
lsd						1.14				1.24	

Table 7 ... Mean curly top and leaf spot resistance for 3 years in tetraploid lines selected for curly top resistance, leaf spot resistance, vigor or dry matter in tetraploid population US 401 and curly top and leaf spot resistance in F_4 tetraploid hybrids.

Populations	No. of lines	Leaf spot resistance				Curly top resistance				Index ct ls
		Mean	Max. -	Min.	Diff.	Mean	Max. -	Min.	Diff.	
L.S. selection	7	3.50	3.90	3.22	0.68	5.40	6.67	3.83	2.84	1.39
C.T. selection	8	3.60	4.06	3.11	0.95	3.83	4.50	2.67	1.83	1.07
Vigor selection	7	3.47	3.83	2.94	0.89	5.17	6.67	4.50	2.17	1.49
Hybrids ct & ls	6	3.58	3.78	3.44	0.34	2.89	3.67	2.00	1.67	0.81
Diploid US 401	1	3.61	between 4n & 2n			8.10	between 4n & 2n			2.24
Tetraploid US 401	1	3.89				4.83				1.24
Diploid S-23-m ²	1	0.89				8.83				9.92
Diploid Klein	1	5.95				9.00				1.51
BETWEEN ALL TETRAPLOIDS	29	4.06			2.34	1.12	6.67	2.00	4.67	
msd						0.86				0.93
lsd						1.14				1.24

SELECTION FOR NON-BOLTING IN TETRAPLOID SUGARBEETS

V. F. Savitsky

The possibility of improvement in tetraploid sugarbeets in bolting resistance was never reported, although polyploid varieties are planted in Europe in areas where non-bolting is important.

It may be expected theoretically that peculiarities of polysomic inheritance, absent in diploids, may complicate in tetraploid selection for non-bolting. The complications are conditioned mainly by the slow segregation (release of potential variability) in tetraploid F₂ and backcross hybrids. The monohybrid segregation ratio in diploids is 3:1, whereas in tetraploids it may be 35:1. Therefore, if the desirable character is controlled by one dominant gene, segregating homozygotes are more rare in tetraploids than in diploids. On the other hand, if a character is controlled by several genes, as in polygenic inheritance of quantitative characters, the peculiarities of segregation in polyploids may show itself as a positive factor, which facilitates the breeding of desirable characters. For example, for obtaining commercial tetraploid hybrids, which exhibit heterosis, the later hybrid generations may be used with better success than in diploid hybrids. Effect of heterosis and the phenotypical stability of hybrids will be maintained in tetraploids for more generations than in the corresponding diploid hybrids. The desirable traits which are well expressed in tetraploids and are controlled by the actions of few recessive genes may easily be used by plant breeders because the constant material is created by selection at once. Such traits may be easily improved in the later generations of tetraploid populations, or hybrids, if a large number of plants is exposed to selection. Genetics of bolting resistance is unknown. It has only been established that the annual character, or the tendency to it, is more or less a dominant character. The pleiotropic action of some deleterious genes (dwarfness, reduction of leaf blades, genes causing chlorophyll deficiencies) delay the bolting of beets. Manifestation of bolting tendency depends upon 2 environmental factors: on the temperature and day length. Both these factors are varying geographically and annually, but they are constant for the field experiment conducted in the same location for any given year. Salinas, California, is such a location, where the climatic conditions permit the classification of sugarbeet genotypes for their inclination to bolting. For this purpose, the diploid and tetraploid sugarbeet stocks were planted since 1961 in overwinter plantings on the field of Spreckels Sugar Company.

MATERIALS AND METHODS

All diploid stocks, as well as all monogerm and multigerm tetraploid stocks, developed by V.F. Savitsky and Helen Savitsky in Salt Lake City, Utah, have never been studied for their bolting tendencies. These stocks were planted for investigation of their bolting tendencies on Experimental Field of Spreckels Sugar Company in Salinas in August of 1961.

Forty self-sterile and self-fertile diploid monogerm stocks and 160 self-sterile and self-fertile monogerm and multigerm tetraploids, as well as some F_1 tetraploid hybrids were included in the experiment. These 200 stocks were grouped in 20 different populations according to their origin and ploidy levels, but the seeds of these stocks were not mixed. Two hundred samples were planted in a completely randomized design; there were 10 replications, each replication containing 1 sample from every population. Plots consisted of 2 rows, fifty feet long. At the time of harvest from 60 to 70 plants grew in each plot. Reading for non-bolting was done in May 1962. The leaves of non-bolted plants were marked by the stain and the necessary quantity of these plants were harvested. The plants selected were exposed to thermal induction in the cold room and then transplanted into the greenhouse at the USDA Station in Salinas. All self-fertile plants were selfed and the self-sterile plants were propagated by brother-sister mating. Seeds were harvested from all plants individually.

Thirty-three tetraploid stocks obtained after selection for non-bolting were planted in the field of Spreckels Sugar Company in August of 1963. These 33 stocks were distributed into 3 following groups of populations according to their types:

1. Monogerm tetraploid self-sterile lines.

The original tetraploid self-sterile monogerm population derived from the diploid self-sterile monogerm population SLC 15. The diploid population of SLC 15 was obtained from backcrosses of the first self-sterile monogerm population SLC 3 to the multigerm population US 35/2. The following entries were planted in the experiment in 1963: Code 1 consisted of 11 tetraploid self-sterile monogerm lines, the progenies of the plants selected for non-bolting in 1962. Code 2, 3, 14, 19 consisted of 44 tetraploid lines of the same origin, but which have never been exposed to selection for non-bolting. Code 19 consisted of lines in which plants were selected for non-bolting in 1962; the progenies of these plants entered into code 1. Code 14 contained 11 lines which were the latest in bolting and flowering in the conditions of Salt Lake City.

2. Monogerm self-fertile tetraploid inbreds.

The tetraploid self-fertile monogerm lines were selected in the F_2 hybrid population derived from hybridization of the tetraploid monogerm inbred SLC 91 with tetraploid multigerm population US 35/2. The multigerm F_1 plants, as well as the F_2 monogerm segregates and the F_3 monogerm plants, were selfed. Code 7 consisted of 11 tetraploid self-fertile monogerm inbreds, the progenies of the plants selected for non-bolting in the lines of the above mentioned origin in 1962. Code 6, 8, 9, 10 consisted of 44 tetraploid self-fertile monogerm inbreds of the same origin which were never selected for non-bolting. Code 9 consisted of lines in which non-bolting plants were selected in 1962; the progenies of these plants entered into code 7. Code 8 contained lines which were the latest in bolting and flowering in the conditions of Salt Lake City.

3. Multigerm self-sterile tetraploid lines.

These lines were isolated in the F_2 hybrid population which derived from hybridization of the tetraploid monogerm population SLC 15 with the tetraploid multigerm population US 35/2. Code 5 consisted of 11 tetraploid multigerm self-sterile lines, the progenies of the plants selected for non-bolting in 1962. Code 4, 16, 17, 18 consisted of 44 tetraploid self-sterile multigerm lines of the same origin which were never selected for non-bolting. Code 4 contained lines in which non-bolting plants were selected in 1962; the progenies of these plants entered into code 5. In the same experiment were also planted 22 stocks of SLC 15, the original monogerm diploid ancestor of the tetraploid self-sterile stocks (entries code 12 and 13). These 187 stocks were grouped according to their origin and levels of ploidy into entries which were randomized and planted in 11 replications on 2-row, 30-foot-long plots.

Reading for bolting resistance was done in May of 1964.

EXPERIMENTAL RESULTS

The analysis of variance for 17 populations is shown in the table 1. Differences in percent of non-bolting plants were not significant for separate replications, but highly significant for the 17 populations studied. Percent of non-bolting plants in individual stocks of 4 tetraploid self-sterile monogerm populations varied from 10.48 to 18.08 (table 2). In the diploid stocks percent of non-bolting plants was a little lower (9.15 to 10.70). But these differences were insignificant. It is interesting to mention that the tetraploid monogerm inbred SLC 91 during 3 years (1961-1964) had many more non-bolting plants than the diploid SLC 91 monogerm inbred.

Considerable progress was made by the non-bolting selection in the tetraploid populations (table 3, 4). The tetraploid self-sterile monogerm populations (code 1) contained 71.43 percent of non-bolting plants. Such a grade of non-bolting resistance should be considered very high, because it does not differ from the bolting resistance of some commercial sugarbeet varieties which are planted in California. At the same time, self-sterile monogerm tetraploid populations (code 2, 3, 14, 19) which were not exposed to selection for bolting resistance contained only 10 to 18 percent of non-bolting plants. Difference in the percent of non-bolting plants between tetraploid populations selected for bolting resistance and the original populations which were not exposed to selection was statistically significant (table 1 and 4).

Selection for bolting resistance in the monogerm self-fertile lines resulted in tetraploid lines which were even more resistant to bolting than the tetraploid self-sterile populations. The average percent of non-bolting plants in the monogerm self-fertile lines equaled 84.70, while in the original tetraploid self-fertile lines percent of non-bolting plants varied from 22.74 to 41.93. These differences in the percent of non-bolting plants between self-fertile progenies, obtained after selection, and the lines which

Table 1 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for percent of sugarbeet non-bolting plants in overwinter planting at Spreckels, California in 1963 and 1964.

	Degree of freedom	Sum of squares	Mean Squares	Variance Ratio	F	
					005	001
Total sum of squares	186	148534.9247				
Between reps	10	2677.5868	267.7587	1.20	1.89	2.44
Between populations	16	110251.4736	6890.7171	30.96	1.71	2.12
Error	160	35605.8643	222.5367	-	-	-

Table 2 ... Percent of non-bolting plants in diploid and tetraploid self-sterile populations of SLC 15 monogerm.

Populations	D I P L O I D S Percent of non-bolters			T E T R A P L O I D S Percent of non-bolters		
	Code No.	Mean	Variation Coefficient	Code No.	Mean	Variation Coefficient
Monogerm self-sterile	12	10.7036	90.53	14	18.0836	48.50
"	13	9.1472	80.35	2	12.4273	71.21
"	-	-	-	3	12.9345	95.33
"	-	-	-	19	10.4755	65.77
Mean		9.9454			13.4802	
lsd					12.5687	
msd					16.5951	

never selected for bolting resistance were always significant statistically. (Table 4).

The multigerm tetraploid populations studied (code 4, 16, 17, 18), which were not selected for bolting resistance, had only 6.5 to 8.8 percent of non-bolting plants. They were less resistant to bolting than many monogerm tetraploid self-sterile, and especially self-fertile stocks (table 4). However, the progenies obtained after selection for non-bolting from these multigerm tetraploids were significantly higher than the original tetraploid multigerm populations not exposed to selection. Such progenies contained 66.58 percent of non-bolting plants, or the number of bolting resistant plants in these selected progenies exceeded by 10 times the number of non-bolting plants in the code 16 population.

Selection for bolting resistance in tetraploids increased the number of lines with high percent of non-bolting plants (table 3), at the same time, the biotypes which had the tendency for easy bolting were lost in the populations. Among tetraploids selected for bolting resistance only few lines had 30 to 50 percent of non-bolting plants. Usually the number of non-bolting plants was higher and some lines did not contain any plants having seed stalks. Such highly bolting resistant lines were never observed in tetraploids which were not exposed to selection. On the contrary, some tetraploid lines not selected for bolting resistance had 100 percent of bolting plants (table 3).

The value of the coefficients of variation, which characterized the variation in percent of non-bolting plants in different stocks within every type of tetraploids, was highly reduced in tetraploids which were exposed to selection. In most cases the values of the coefficients of variation were twice as large in the tetraploids which were not selected as those in tetraploids selected for bolting resistance (table 4).

CONCLUSION

1. The tetraploid monogerm and multigerm populations obtained from diploid populations which were never exposed to selection for non-bolting were not uniform in bolting tendency. The non-bolting plants were more often observed in the monogerm than in the multigerm populations.

2. Selection for bolting resistance appeared to be highly effective in monogerm and in multigerm tetraploid populations. Even one selection for non-bolting produced many progenies in which plants developing seed stalks were very rare. Effectiveness of selection for bolting resistance was higher in self-fertile tetraploid stocks than in the tetraploid self-sterile populations propagated by brother-sister mating.

I express my appreciation to G.W. Wheatley and to Y.D. Schulke for conducting the field experiments at Spreckels, California.

Table 4 ... Percent of non-bolting plants in tetraploid monogerm and multigerm sugarbeet populations without selection and after one selection for non-bolting.

Populations	Without selection			Selection for n/b		
	Percent of non bolters			Code No	Percent of non bolters	
	Code No	Mean	Variation Coefficient		Mean	Variation Coefficient
Monogerm self-sterile tetraploids	14	18.0836	48.50	1	71.9291	9.95
" "	3	12.9345	95.33			
" "	2	12.4273	71.91			
" "	19	10.4755	65.77			
Monogerm self-fertile tetraploids	8	41.9327	65.80	7	84.7045	39.22
" "	9	32.6155	79.90			
" "	6	22.7473	79.00			
" "	10	22.7436	114.67			
Multigerm self-sterile tetraploids	4	8.8327	91.93	5	66.5755	39.17
" "	18	7.3973	82.60			
" "	17	7.2209	105.8			
" "	16	6.5364	87.14			
lsd		12.5687	-	-	12.5687	
msd		16.5951	-	-	16.5951	

COMBINING ABILITY IN TONNAGE AND SUCROSE IN SINGLE-CROSS AND IN THREE-WAY DIPLOID, TRIPLOID AND TETRAPLOID MALE-STERILE MONOGERM HYBRIDS.

V. F. Savitsky.

Different tetraploid self-sterile and self-fertile sugarbeet stocks have been developed to study the combining ability in polyploids. Some of the tetraploid stocks studied were produced by H. Savitsky by colchicine treatment, the others derived from hybridization of earlier produced tetraploids and propagation of hybrids by different mating systems. In such a way, the origin and the mode of propagation of the monogerm and multigerm tetraploid stocks used in the experiment was experimentally controlled. The tetraploid stocks obtained differed in tonnage, in percent sucrose, and in resistance to diseases.

American and European sugarbeet populations and lines are usually characterized by the optimal expression of 1 character for which they were selected; as, for example, by a high sucrose content, or by resistance to a certain disease, and so on. It takes usually many years of breeding work for development of such diploid populations.

The autotetraploids, obtained by colchicine treatment from such diploid populations, often also exhibited the optimal expression of 1 character only. However, our experiments indicated that tetraploidy makes possible the accomplishment of several breeding projects. For instance, the combination (in 1 tetraploid population and then also in the triploid male-sterile hybrids) of several characters at a higher grade of expression than they were expressed in the diploid parental populations, or in the diploid hybrids.

This paper reports the results of evaluation of diploid, triploid and tetraploid monogerm male-sterile hybrids and their parental populations with respect to root yield and percent sucrose. The populations tested are characterized by a high grade of resistance to different diseases. In some of these tetraploids the resistance to different diseases is combined at a higher level than that in their original diploid populations.

MATERIALS AND METHODS

The triploid and tetraploid male-sterile monogerm hybrids were obtained after hybridization of diploid and tetraploid male-sterile monogerm strains with the diploid or tetraploid pollinators.

Advanced generations of some tetraploid self-sterile hybrids were used for production of three-way hybrids with the purpose of studying the possibility of substitution of the single-cross hybrids for the three-way monogerm male-sterile hybrids.

The experiment was planted in 10 replications in a randomized complete block design April 7, and harvested October 20, 1964. The previous crop was barley. Fertilization consisted of 900 pounds of 10-10-5 fertilizer per acre as a preplant application and 2 side dressings of 400 pounds of 16-20 mixture per acre. Single-row plots were used and the plots were spaced 28 inches apart. Irrigations were applied at 7-day intervals by furrows from time of planting. Plants were sprayed to control leaf minor. No bolting or curly top damage was observed in the experiment. Stand of all populations was full. Virus yellow infection was very high and its distribution in field was uniform. Spots with different color of leaves were absent. Individual lines differed in degree of yellowing, but all populations showed signs of infection.

Yield and percent sucrose in the stocks studied and in the commercial multigerm check are shown in tables 4 to 9. In the experiment of 1963 the variety US 75 was used as a check, and in 1964 the check was the multigerm male-sterile hybrid H-6.

Degrees of freedom, sum of squares and sources of variation in analysis of variance of root weight and percent sucrose are shown in the tables 1 and 2. There were highly significant differences between populations in yield and percent sucrose, but no significant differences between blocks.

EXPERIMENTAL RESULTS

Hybrids from highly curly top resistant tetraploid monogerm and multigerm inbreds.

The monogerm and multigerm tetraploid lines and triploid hybrids obtained from them were tested for curly top resistance at Logan (Thatcher), Utah in 1964. Some of these tetraploid lines showed a high grade of resistance to curly top. Four lines in this highly resistant group were tested for tonnage and percent sucrose at Salinas in 1964 (table 3).

The multigerm tetraploid inbred S-168 was the most curly top resistant line in the test. Its grade of resistance was 1.17. Only 16.38% of plants in this line showed signs of curly top infection in August. The susceptible to curly top diploid variety Klein E contained 98.5% infected plants, many of which were almost destroyed by curly top. The curly top resistant diploid variety US 35/2 had 40.1% of plants with signs of infection at this time.

The monogerm triploid hybrids derived from pollination by the line S-168 also showed high resistance (2.0), and contained a very low percent of plants (17.8) slightly damaged by the virus.

The inbred S-168 tested in Salinas was significantly higher in percent sucrose than the commercial check, but significantly lower in tonnage.

Table 1 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for weight of roots in 28 populations of diploid, triploid and tetraploid hybrids and lines.

Sources of Variation	Degree of freedom	Sum of squares	Mean Squares	Variance Ratio	F	
					005	001
Total sum of squares	279	12561.30	-	-	-	-
Sum of blocks	9	764.66	84.96	6.15	1.92	2.50
Sum of populations	27	8440.10	312.60	22.63	1.57	1.88
Error	243	3356.54	13.81	-	-	-

Table 2 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for percent sucrose in 28 populations of diploid, triploid and tetraploid hybrids and lines.

Sources of Variation	Degree of Freedom	Sum of Squares	M e a n Squares	Variance Ratio	F	
					005	001
Total sum of squares	279	332.05	-	-	-	-
Sum of Blocks	9	2.48	0.27	0.57	1.92	2.50
Sum of populations	27	211.57	7.84	16.14	1.57	1.88
Error	243	117.99	0.48	-	-	-

Table 3 ... Evaluation of curly top resistance in tetraploid pollinators and in triploid and tetraploid monogerm male-sterile hybrids.
Test 1964. Thatcher, Utah.

Tetraploid Pollinators	C u r l y t o p r e s i s t a n c e i n					
	Pollinators		Triploid hybrids		Tetraploid hybrids	
	Code No,	Grade of Infec- tion	% of plants infected by curly top	Grade of Infec- tion	% of plants infected by curly top	% of plants infected by curly top
Multigerm self-fertile	S-168	1.17	16.38	2.00	17.8	12.0
Monogerm self-fertile	S-127	1.42	19.15	2.50	31.0	9.8
Monogerm self-fertile	S-77	1.62	19.53	2.25	38.2	-
Multigerm F ₄	15 x 401	2.75	38.78	2.25	28.6	9.1
Multigerm Janasz	143	-	-	4.25	49.83	-
Diploid US 401		8.0	73.7			
Diploid US 35/2		3.0	40.1			
Diploid Klein		8.5	98.5			

The triploid hybrids obtained from S-168 showed during 2-year tests in Salinas significantly higher yield and the same percent sucrose as the inbred S-168. In this way, in the triploid hybrid derived from S-168 a high grade of curly top resistance was combined with a good sugar content and yield (table 4).

Two monogerm self-fertile tetraploid inbreds S-127 and S-77 also showed high resistance to curly top in the test in Logan (table 3). The grade of resistance shown in these lines was 1.42 and 1.62, respectively. They contained about 19% of the plants slightly damaged by curly top. The triploid hybrids obtained from these inbreds also had good curly top resistance, which was not lower than the grade of resistance of the diploid multigerm population 35/2.

The monogerm tetraploid inbred S-127 and its male-sterile hybrid were tested for 2 years at Salinas (table 5). Although the inbred S-127 was used as a monogerm pollinator, the triploid male-sterile hybrids obtained were good in yield and in percent sucrose.

The inbred line S-77 was tested at Salinas only in 1964. Triploid hybrids obtained from this line also showed a good yield and percent sucrose (table 6).

Monogerm male-sterile three-way hybrids derived from hybridization of diploid male-sterile line with tetraploid hybrid population.

The F_4 open-pollinated hybrid populations, used as pollinator, were derived from hybridization of 2 tetraploid self-sterile populations. One of these populations was SLC 15 monogerm which had a medium grade of resistance to curly top; the other, US 401, had about the same grade of resistance to leaf spot as the diploid US 401.

The F_4 hybrid population was tested for leaf spot resistance in Fort Collins, Colorado. Its for 3 years average grade of resistance to leaf spot was 3.47, whereas the resistance of the diploid population of US 401 was 3.83. This F_4 tetraploid hybrid population was tested also for curly top resistance at Logan, Utah. Its grade of resistance to curly top was 2.75, whereas the average resistance of the diploid population US 35/2 was 3.0 (table 3). Thus, in this tetraploid F_4 hybrid population which has never been selected for curly top, or for leaf spot resistance, the resistances to both diseases were combined at the same levels as in the commercial diploid populations.

The open-pollinated tetraploid hybrid (SLC 15 mm x US 401) during 2-year tests at Salinas significantly exceeded the commercial check in yield and in percent sucrose (table 7). Because of its resistance to diseases and high productiveness, the tetraploid hybrid (SLC 15 mm x US 401) was used as a pollinator for diploid monogerm line for production of three-way monogerm triploid commercial hybrids.

Table 4.... Tonnage and sucrose in F₁ MS monogerm diploid, triploid and tetraploid hybrids derived from pollination by self-fertile diploid and tetraploid inbred S-168 Salinas, California.

Populations	Code	Tons of roots		Percent sucrose	
		1963	1964	1963	1964
Pollinator	155	13.40	10.43	15.11	17.41
F ₁ Tetraploid hybrid	153	17.26	15.18	15.50	17.25
F ₁ Triploid hybrid	154	21.11	15.22	14.97	17.39
F ₁ Diploid hybrid	133	18.78	-	15.05	
Multigerm commercial diploid		16.41	12.21	14.10	16.41
msd		2.47	1.39	0.53	0.62
lsd		3.26	1.83	0.70	0.81

Table 5 ... Tonnage and sucrose in F₁ MS monogerm diploid, triploid and tetraploid hybrids derived from pollination by self-fertile diploid and tetraploid inbred S-127. Salinas, California

Populations	Code		Tons of roots		Percent sucrose	
	1963	1964	1963	1964	1963	1964
Pollinator	134	139	14.92	10.64	14.93	16.97
F ₁ tetraploid hybrid	135		17.53		14.93	
F ₁ triploid hybrid	152	138	22.60	13.65	14.65	17.37
F ₁ diploid hybrid	139		16.45		14.58	
Multigerm commercial diploid			16.41		14.10	16.41
msd			2.47	1.39	0.53	0.62
lsd			3.26	1.83	0.70	0.81

Table 6 ... Tonnage and sucrose in F₁ MS monogerm triploid hyb rid derived from
pollination by monogerm curly top resistant tetraploid inbred S-77.
Test 1964. Salinas, California.

Populations	Code	Tons of roots	Percent sucrose
Pollinator	140	12.34	17.47
F ₁ Triploid hybrid	141	12.97	17.29
Multigerm commercial diploid	-	12.12	16.41
msd		1.39	0.62
lsd		1.83	0.81

Table 7 ... Tonnage and sucrose in F_1 MS monogerm diploid, triploid and tetraploid hybrids derived from pollination by self-sterile diploid and tetraploid hybrid populations of SLC 15 x US 401. Salinas, California.

Populations	Code		Tons of roots		Percent sucrose	
	1963	1964	1963	1964	1963	1964
Pollinator	136	148	20.82	15.60	14.77	16.96
F_1 Tetraploid hybrid	140	149	19.55	15.14	14.56	16.33
F_1 Triploid hybrid	148	151	23.19	14.54	14.75	17.16
F_1 Diploid hybrid	141	152	19.97	11.41	14.58	16.67
Multigerm commercial diploid			16.41	12.21	14.10	16.41
msd			2.47	1.39	0.53	0.62
1sd			3.26	1.83	0.70	0.81

The three-way triploid hybrid obtained from this pollinator was tested at Salinas in 1963 and 1964 and exceeded the commercial check in yield and percent sucrose (table 7). The grade of resistance to curly top in this triploid hybrid was about the same as in the diploid US 35/2 (table 3).

Besides the three-way monogerm triploid hybrid $2n$ MS x ($4n$ SLC 15 x US 401), the corresponding three-way monogerm diploid hybrid $2n$ MS x ($2n$ SLC 15 x US 401) was tested during 2 years on the experimental field of Salinas. The diploid and triploid three-way hybrids differed only a little in percent sucrose, but the yield was significantly higher in the corresponding triploid hybrid (table 7).

Monogerm male-sterile hybrids with high percent sucrose.

The tetraploid multigerm self-sterile population (code 143) was obtained from the diploid variety Janasz after colchicine treatment. The monogerm triploid and tetraploid hybrids produced from pollination by the tetraploid population 143 had a very high percent sucrose, in the test at Salinas, and significantly exceeded the commercial check in yield (table 8).

The diploid variety Janasz (code 142) also had a very high percent sucrose, but its yield was significantly lower, not only in comparison with the triploid hybrid, but also with the tetraploid population of Janasz (code 143) (table 8).

All male-sterile hybrids obtained from pollination by the variety Janasz, regardless of the ploidy levels, showed in all cases a lower percent sucrose than the original diploid and tetraploid populations of Janasz, but the differences were not significant. (table 8).

In spite of this, the monogerm triploid male-sterile hybrid obtained from Janasz had 15.45% and 18.29% percent sucrose in the 1963 and 1964 tests, and exceeded very much the commercial check which had 14.10% and 16.41% sucrose in the same years. The differences between the commercial check and the monogerm triploid hybrids in the 2-year tests were 1.35% and 1.88% sucrose, respectively.

The grade of curly top resistance of the triploid monogerm male-sterile hybrid ($2n$ MS mm x $4n$ Janasz) in the test at Logan was 4.25, whereas the diploid and tetraploid original populations of Janasz are curly top susceptible populations. (Table 3)

Tetraploid sugarbeet hybrids and populations.

It is usually considered that tetraploids are valuable only as pollinators for production of triploid hybrids. The study of different tetraploid sugarbeet stocks indicates, however, that such a concept is not in accordance with the correct and complete evaluation of the usefulness of tetraploid sugarbeet stocks for agriculture. The possibilities of the use of tetraploids are not discussed in this paper, but it may be

Table 8 ... Tonnage and sucrose in F₁ MS monogerm diploid, triploid and tetraploid hybrids derived from pollination by self-sterile high in sucrose diploid and tetraploid populations of Janasz. Salinas, California.

Populations	Code	Tons of roots		Percent sucrose	
		1963	1964	1963	1964
Tetraploid multigerm parental population	143	19.84	13.44	16.08	18.96
F ₁ Tetraploid hybrid	147	21.07	13.95	15.78	17.96
F ₁ Triploid hybrid	145	23.19	15.82	15.45	18.29
F ₁ Diploid hybrid	146	19.29	11.96	15.69	17.89
Diploid multigerm parental population	142	16.71	8.99	16.18	18.49
Multigerm commercial diploid		16.41	12.21	14.10	16.41
msd		2.47	1.39	0.53	0.62
lsd		3.26	1.83	0.70	0.81

stated that many tetraploid populations such as Janasz 143, US 401, open pollinated hybrid SLC 15 x US 401, etc., as well as some tetraploid male-sterile hybrids are distinguished by a high percent sucrose, or by yield. They have also a higher grade of resistance to curly top than the corresponding diploids (table 3). The monogerm self-sterile and self-fertile tetraploids develop large fruits. The tetraploid monogerm equivalents of inbred lines may increase the productiveness of some diploid lines which possess valuable characters. For example, the monogerm diploid inbred S-23 was graded 0.89 in the triennial tests for leaf spot resistance at Fort Collins, Colorado. This grade of resistance significantly exceeded the grade of leaf spot resistance (3.61) in the diploid population of US 401. Because of its high homozygosity (S_5 generation), the inbred S-23 was low in yield; the weight of roots in this line was only 50% of that of the commercial check. The inbred S-23 showed a good combining ability, and the diploid male-sterile hybrids obtained from this inbred did not differ significantly in yield from the multigerm commercial check (table 9). The triploid male-sterile hybrids obtained from hybridization of the tetraploid male-sterile line with the inbred S-23 exceeded the commercial check significantly in yield and in percent sucrose.

CONCLUSION

1. Tetraploid open-pollinated populations, in which the resistance to curly top and to leaf spot was combined at the levels of the diploid original varieties, showed a good vigor and yield.
2. Triploid three-way monogerm male-sterile hybrid, obtained from pollination of the monogerm, diploid male-sterile line by the tetraploid F_4 hybrid population in which the resistance to curly top and leaf spot was combined, exceeded in yield the corresponding diploid three-way hybrid. At the same time the grade of curly top resistance in this triploid hybrid was close to that of the diploid parental variety.
3. Tetraploid stocks with a very high grade of resistance to curly top, used as pollinators, produced triploid hybrids high in curly top resistance. Some of these hybrids also showed a good yield and high sucrose.
4. The experiment showed that by using tetraploid pollinators high in sucrose it is possible to produce monogerm male-sterile triploid hybrids which are higher in sucrose by 1.3% - 1.8% percentage points than the commercial diploid checks.

Table 9 ... Tonnage and sucrose in F₁ MS monogerm diploid and triploid hybrids derived from pollination of diploid and tetraploid MS by leaf spot resistant non-bolting inbred S-23. Test 1964. Salinas, California

Populations	Tons of roots	Percent sucrose
Diploid monogerm self-fertile inbred S-23	6.23	17.36
F ₁ Diploid hybrid	12.80	16.90
F ₁ Triploid hybrid	13.78	17.78
Multigerm commercial diploid	12.21	16.41
msd	1.39	0.62
lsd	1.83	0.81

INTERSPECIFIC HYBRIDIZATION

Helen Savitsky

To maintain the basic group of F_1 hybrids and to substitute some old hybrids by the new ones, new crosses between B. vulgaris and species of the section Patellares are continuously being made and new hybrids produced.

Cytogenetic study, growing of the next b_1 and F_2 hybrid generations, and tests of hybrids for resistance to sugarbeet nematods (Heterodera Schachtii) are being continued.

Transmission of characters of wild species into b_1 generation and selection for nematode resistance.

A study of meiosis in F_1 hybrids indicated the possibility of transmission of chromosomes and genes from Patellares species into species of B. vulgaris. Vulgares-Patellares hybrids, as shows their meiosis, cannot breed through and establish new species because the pairing of chromosomes is not exclusively autosyndetic. Beta vulgaris chromosomes do not pair exclusively between themselves, chromosomes of different species associate to some extent with each other. Therefore, these hybrids are in unstable condition. They must return in succeeding generations to either one of the parental species. At the same time they may transmit some chromosomes and segments of chromosomes from one species into genome of another species.

Only those gametes of F_1 hybrids were viable which carried either a complete set of chromosomes of B. vulgaris, or a set of chromosomes of B. vulgaris with addition of 1 or 2 chromosomes - in some cases alien chromosomes.

The characters of wild species may be transmitted from F_1 hybrids to b_1 generation 1) by segmental interchanges due to translocations and crossingover and incorporation of segments of chromosomes of wild species into the chromosomes of B. vulgaris, and 2) by the supplement of single chromosomes from wild species to the set of B. vulgaris chromosomes.

Transmission of 4 characters from F_1 to the first backcross generation was studied: 1) inviability of seedlings, 2) formation of genetic tumors, 3) annual character, and 4) resistance to sugarbeet nematode.

1) Some b_1 seedlings were inviable like F_1 hybrid seedlings. They did not develop a root system and perished after having developed the first pair of rudimental leaves.

2) Like interspecific hybrids in Nicotiana, genetic tumors were often formed in F_1 Vulgares-Patellares hybrids. Little tumors started on the

stem, or on the leaf blades, then they developed into bushy balls consisting of many little sprouts. In b_1 hybrids such tumors developed on the roots, on the leaves, on the petioles, and on seed balls.

Of 17 plants having tumors examined for chromosome number 6 plants had 18 chromosomes, and 11 had additional chromosomes. Of these 11 plants with additional chromosomes, 6 had 19 chromosomes, 3 had 20 chromosomes, 1 had 21 chromosomes and 1 had 29 chromosomes. There is no doubt that the additional chromosomes transmitted from wild species were responsible for the formation of tumors. The plants with 18 chromosomes which developed tumors obviously carried segments of chromosomes of wild species which were responsible for tumors formation.

3) The majority of b_1 plants were biennial, but some hybrids in this generation did not develop fleshy roots and at the stage of several pair of leaves formed the seed stalks and flowered in the first year. Some of these annual plants had red pigmentation on the stem or on petiole. Nine annual plants were examined for chromosome number. Four of them had 18 chromosomes, 4 had 19 chromosomes, and 1 plant had 20 chromosomes.

4) To test the hybrids for nematode resistance the b_1 seedlings were transplanted in nematode infested soil and examined for the presence of females on the roots after 60 days of growth. Plants heavily infested were discarded, and those with few nematodes on the roots (1 to 10) were selected and transplanted again in nematode infested soil for a repeated test. Depending upon the vigor, hybrids were tested from 1 to 3 times. Six hundred and seventy b_1 plants were tested for resistance; of which 47 plants were selected. The selected plants had from 0 to 10 cysts on the roots. The majority of selected hybrids had 2 to 6 females on the roots.

Forty plants selected for nematode resistance were checked for the number of chromosomes. Of these, 26 plants had 18 chromosomes, 7 plants had 19 chromosomes, 4 plants had 20 chromosomes, and 1 plant had 21 chromosomes.

Frequency of transmission to b_1 generation was different for individual characters, being 6.0% for inviability of seedlings, 8.5% for tumor formation, 2.8% for the annual character, and 7.0% nematode resistance. (table 1).

Forty-seven b_1 plants selected for nematode resistance were exposed to thermal induction. Forty plants survived until spring and were transplanted to the greenhouse for seed production. Development of plants was not uniform, some of them started to flower 2 months later than the others. All plants selected were kept in greenhouse for seed setting.

Of the 40 plants, 20 developed tumors, and 3 were annuals. Tumors developed as galls on the roots, or as brushes or balls consisting of a mass of sprouts on the top of the roots, on the stems, on leaves, and even on seedballs. Several plants which developed galls on the roots died before forming seed stalks. The whole group of plants selected for nematode resistance exhibited different sorts and degrees of sterility. The plants having 20 and 21 chromosomes were male- and female-sterile. Two plants with tumors on the fruits started to set seeds, but they became aborted. Many plants were partially sterile, and only a few plants had normal seed setting. Deviation from the normal type of development as indicated by formation of tumors and manifestation of sterility; indicated undoubtedly that plants selected for nematode resistance carried some chromosomes and segments of chromosomes of wild species which were responsible for these abnormalities.

The b_2 seeds were harvested from 14 plants. Seeds of some of these plants have been planted in the greenhouse and seedlings which came up were transplanted into nematode infested soil. The b_2 hybrids are now under investigation for resistance to sugarbeet nematode.

I express my appreciation to Charles Price who supplied me with nematode infested soil and cooperated in screening for resistance until June 1964.

Table 1 ... Transmission of characters from F_1 to b_1 generation in Vulgares-Patellares hybrids.

Characters studied	Number of b_1 plants examined	Number of b_1 plants with character studied	Percent transmission
Inviability of seedlings	465	28	6.0
Formation of genetic tumors	400	34	8.5
Annual character	400	11	2.8
Resistance to sugarbeet nematode	670	47	7.0

PRODUCTION OF TETRAPLOID STRAINS

Helen Savitsky

1. C_0 tetraploid plants were selected in 2 monogerm inbred lines during the summer of 1963. Seeds, obtained from selfing and intercrossing within a line of selected tetraploid plants, were planted in the fall of 1963. During the winter of 1964 the young C_1 plants were checked for chromosome numbers. The selected tetraploid plants were exposed to thermal induction and transplanted in the spring in isolated plots for production of tetraploid inbred lines.
2. The following sugarbeet stocks were treated by colchicine in the fall of 1963: 2 monogerm O-type inbred lines, 2 monogerm leaf spot resistant inbreds, 1 self-sterile multigerm population good in combining ability, and 1 self-sterile monogerm population. The treated seeds were planted and the affected seedlings were exposed to thermal induction. In the summer of 1964, tetraploid C_0 plants were selected in these stocks on the basis of size of pollen grains. Seeds obtained from the selected plants were planted in the fall for determination of chromosome numbers and selection of C_1 tetraploid plants during the winter 1964-65. The tetraploid plants selected in all stocks will be propagated in 1965.

A total of 756 C_0 plants were investigated for the size of pollen grains and 420 C_1 plants were examined for the number of chromosomes in 1964.

A study of the effect of different colchicine concentrations is being continued.

A STUDY OF OVULE DEVELOPMENT AND FRUIT GERMINATION IN DIPLOID, TRIPLOID AND TETRAPLOID SUGARBEET SEEDS.

Helen Savitsky, Ralph E. Finkner, C.W. Doxtator, Curzon Kay, Norman Lawlor.

Triploid monogerm hybrids obtained from pollination of diploid male-sterile monogerm lines by tetraploid populations often exhibit high productiveness or a high yield of sucrose. Their use in commercial crop production requires a high quality and a sufficient germination ability of the triploid seeds. There is some indication that triploid sugarbeet hybrid seeds are lower in their germination than the diploid ones. Because of the importance of this factor, investigations were started to verify this statement and to reveal the cause of its occurrence. For a study of development and germination of fruits, breeding materials of the American Crystal Sugar Company were used.

MATERIALS AND METHOD

For a comparison of the triploid and diploid hybrid seeds the fruits of a diploid male-sterile line pollinated by the diploid and tetraploid populations were studied. The diploid and tetraploid pollinators were also included in the investigation. Material was collected on 4 isolations near Clarksburg, California.

On isolation 1- the diploid monogerm male-sterile line 569-H3 was pollinated by the diploid monogerm population 64-202. Diploid monogerm seeds of 5 plants were investigated in each population.

On isolation 2 the same diploid monogerm male-sterile line 569-H3 was pollinated by the tetraploid multigerm population GTY-74862. Triploid monogerm seeds and tetraploid multigerm seeds of 5 plants were investigated in each population.

On isolation 3 diploid monogerm male-sterile line 569-H3 was pollinated by the diploid multigerm population of GTCR-74842. Diploid monogerm seeds of plants in male-sterile line were investigated.

On isolation 4 tetraploid multigerm seeds of 3 plants in the open-pollinated tetraploid population of 64-2T were investigated.

Investigation concerned : a) examination of ovules for determination of percent of non-fertilized ovules, fertilized and normally developed ovules, and fertilized but aborted ovules, and b) germination test of fruits from each investigated plant. From each plant two branches were collected. On each branch were examined 50 fruits (2 replications). The cap on the fruit was removed and the ovary opened.

The non-fertilized ovules were small, dark lumps lying on the bottom of the ovary and surrounded by an empty space in the ovary. The ovary continued to grow to some extent when non-fertilized ovules ceased their growth. Fertilized and normally developed ovules are large, covered by the brown seed coat, and well filled. If crushed the embryos and, sometimes, the milky starch can be observed. The fertilized and aborted ovules are also comparatively large, covered by the brown seed coat, but they are shrivelled, thin and empty when crushed. The number of non-fertilized, normal and aborted ovules was determined in 100 fruits per plant. The male-sterile populations and the populations of pollinators flowered at the same time. Plants in the populations of pollinators were twice as tall as male-sterile plants and produced sufficient pollen for a successful pollination.

For a germination test, seeds were harvested individually from all plants investigated. The samples, each containing 50 fruits (100 fruits per plant), were taken from each plant for germination test. Seed germination test was done in Rocky Ford, Colorado.

In multigerm beets, besides the determination of percent of germination and percent of different kinds of ovules per 100 fruits, the analyses of these characteristics was done separately for fruits with different number of locules.

EXPERIMENTAL RESULTS

Examination of diploid and triploid fruits in the monogerm male-sterile and open-pollinated populations.

Percent of unfertilized ovules in the monogerm male-sterile line 569-H3 did not differ, whichever pollinator was used. Percent of unfertilized ovules in this line was 13.2 when pollinated by the diploid monogerm population, 13.8 when pollinated by the diploid multigerm population, and 13.8 when pollinated by the tetraploid multigerm population (table 1, 2, 3 and 4).

No statistical differences in percent of unfertilized ovules were proved between 3 male-sterile populations pollinated by different pollinators (table 5). However, individual plants within populations differed significantly. Variation in percent of unfertilized ovules was comparatively large in all male-sterile populations regardless of the kind of pollinators.

Immediately after fertilization, embryos and endosperm start to develop and the ovules enlarge and grow simultaneously with the growth of the fruits. They completely fill the cavity of the ovary. The majority of the ovules develop normally and produce viable seeds, but in some the normal course of development is interrupted and they become aborted.

Percent of normally developed ovules was high in all 3 male-sterile populations: 76.0 in the male-sterile population pollinated by tetraploid population of GTY-74862 (3n seeds), 78.6 in the population

Table 1 ... Percent of unfertilized, fertilized normal and aborted ovules, and germination in 2n monogerm fruits of 5 plants in MS 569-H3 2n monogerm x 64-202 2n monogerm.

Plants No.	Ovules-100 per plant			Germination per 100 fruits	Sprouts obtained
	Unferti-lized	Fertilized Normal	Aborted		
1	11	81	8	92.5	92.5
2	12	86	2	96.5	96.5
3	13	75	12	80.5	80.5
4	10	77	13	70.5	70.5
5	20	74	6	95.5	95.5
Mean	13.20	78.6	8.20	87.0	87.0

Table 2 ... Percent of unfertilized, fertilized normal and aborted ovules, and germination percent in 3n monogerm fruits of 5 plants in MS 569-H3 2n monogerm x GTY-74862-4n multigerm.

Plants No.	Ovules-100 per plant			Germination per 100 fruits	Sprouts obtained
	Unferti-lized	Fertilized Normal	Aborted		
6	11	82	7	60.5	60.5
7	15	81	4	70.5	70.5
8	18	74	8	49.5	49.5
9	11	68	21	10.0	10.0
10	14	75	11	63.0	63.0
Mean	13.8	76.0	10.2	50.7	50.7

Table 3... Percent of unfertilized, fertilized normal and aborted ovules, and germination percent in 2n monogerm fruits of 5 plants in MS 569-H3 2n monogerm x GTCR-74842 2n multigerm.

Plants No.	Ovules-100 per plant			Germination per 100 fruits	Sprouts Obtained
	Unferti- lized	Fertilized Normal	Aborted		
16	6	90	4	91.0	91.0
17	13	85	2	95.0	95.0
18	14	77	9	90.0	90.0
19	17	77	6	58.5	60.5 2.0 twins
20	19	81	0	88.5	88.5
Mean	13.8	82.0	4.2	84.6	85.0

Table 4 ... Average percent of unfertilized, fertilized normal and aborted ovules and germination percent in 3 male-sterile populations of 569-H3 2n monogerm

Male-sterile Populations	Ovules-100 per plant			Germination per 100 fruits	Sprouts obtained
	Unfertilized	Fertilized Normal	Aborted		
MS m ² x m ² (2n mono fruits)	13.2	78.6	8.2	87.0	87.0
MS m ² x M ⁴ (3n mono fruits)	13.8	76.0	10.2	50.7	50.7
MS m ² x M ² (2n mono fruits)	13.8	82.0	4.2	84.6	85.0

pollinated by a diploid monogerm population (2n seeds), and 82.0 when male-sterile line was pollinated by the diploid multigerm population (2n seeds) (table 1, 2, 3, 4). Although maintained at a high level, percent of normally developed ovules was the lowest in triploid seeds and the highest in diploid seeds, resulting from pollination by a multigerm population.

Difference in percent of normally developed ovules between the male-sterile populations was proved statistically, because the value of estimated variance ratio 9.0875 exceeds the F value of 4.46. Also, differences between individual plants in percent of normally developed ovules within each male-sterile population were still higher and were significant. The variance ratio equaled 17.6339. Difference between replications was significant (table 6).

Aborted ovules were found in all male-sterile populations. But the percent of such ovules was comparatively low: it varied from 4.2 when the male-sterile line was pollinated by the diploid multigerm beets (2n seeds), to 8.2 after pollination by the diploid monogerm population (2n seeds), to 10.2 in triploid seeds derived from pollination by tetraploid multigerm population (table 1, 2, 3, 4). No statistical difference was found between replications. Difference in percent of aborted ovules between male-sterile populations, and especially between different plants within the populations, were statistically proved (table 7). The male-sterile populations, regardless of the kind of pollinator, contained plants with very low percentage of aborted ovules (0, 2, 4) and the plants in which percent of aborted ovules reached 12, 13 and 21.

Germination of monogerm fruits was high in both male-sterile populations pollinated by the diploid beets (2n seeds). After pollination by the monogerm population germination was 87.0%, and after pollination by the multigerm population it was 84.6%. Germination of triploid seeds (table 3) in male-sterile line pollinated by the tetraploid GTY-74862 population was lower (50.7%). Difference in germination between male-sterile populations is significant: the variance ratio is 56.13, whereas the tabulated value at 0.01 is 8.65 (table 8). Difference in percent of germination between plants within populations is also large. Usually, with few exceptions, plants having a lower percent of aborted ovules exhibited a higher percent germination. Obviously, percent of seed germination and percent of aborted ovules cannot be identical, because the ovules examined on 2 branches cannot correspond exactly with sample of seed taken from the given plant. At the same time analysis of ovules indicated the general tendency of a plant to develop normal and aborted fruits. Percent of germination of triploid seeds is lower than had been expected on the basis of the amount of the aborted ovules. It might be possible that some of the ovules were morphologically normally developed, but their physiological functions were not complete, and biochemical processes which lead to transmission of seed from the stage of dormancy to the stage of germination were delayed in some fruits.

Table 5 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for unfertilized ovules in 3 male-sterile populations of 569-H3 2n monogerm.

Sources of Variation	d.f.	Sum of squares	Mean squares	Variance Ratio	F	
					005	001
Total sum of squares	29	523.2000				
Reps	1	0.5333	0.5333	small	4.46	8.65
Between plants in populations	4	392.8000	98.2000	16.6664	4.46	8.65
Between MS populations	2	0.2400	0.1200	small	4.46	8.65
Error	22	129.6267	5.8921 *			

*) significant

Table 6 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for fertilized normal ovules in 3 male-sterile populations of 569-H3 2n monogerm.

Sources of Variation	d.f.	Sum of squares	Mean squares	Variance ratio	F	
					005	001
Total sum of squares	29	1132.3878				
Reps	1	29.9211	29.9211	3.0047	4.46	8.65
Between plants in populations	4	702.4000	175.6000	17.6339	4.46	8.65
Between MS populations	2	180.9878	90.4939	9.0875	4.46	8.65
Error	22	219.0789	9.9581			

Table 7 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for fertilized aborted ovules in 3 male-sterile populations of 569-H3 2n monogerm.

Sources of Variation	d.f.	Sum of squares	Mean squares	Variance ratio	F	
					005	001
Total sum of squares	29	997.4674				
Reps	1	22.5341	22.5341	2.6445	4.46	8.65
Between plants in populations	4	600.8000	150.2000	176.2663 *	4.46	8.65
Between MS populations	2	186.6674	93.337	10.9531 *	4.46	8.65
Error	22	187.4659	8.5212			

*) significant

Table 8 ... Mean squares, degrees of freedom and sources of variation in analysis of variance for germination in 3 male-sterile populations of 569-H3 2n monogerm.

Sources of Variation	d.f.	Sum of Squares	Mean squares	Variance ratio	F	
					005	001
Total sum of squares	14	7792.10				
Between plants in populations	4	734.18	183.545	small	4.46	8.65
Between MS populations	2	4121.10	2060.550	56.1300	4.46	8.65
Error	8	2936.82	367.1025			

Examination of ovules in the diploid monogerm pollinator 64-202 showed that also in the open pollinated diploid self-sterile population some ovules were unfertilized (table 9). Their number (22.2%) was even higher than in male-sterile plants which grew on the same isolation (13.2%).

Percent of normally developed ovules in the population of pollinator was a little lower (71.6%) and percent of aborted ovules a little higher (6.2) than in male-sterile plants pollinated by this population on the same isolation (table 9).

Percent of fruits germination in the population 64-202 was high and equaled 92.6.

Examination of tetraploid fruits in the multigerm tetraploid populations.

In the multigerm populations, as in all monogerm populations, examination of ovules was started with fruits at the bottom of the branches, and extended to about 2/3 of the length of the branch. Ovules in the fruits on the upper part of the branches could not be examined because of their immaturity. The upper part of the branches was often still in blossom. Therefore, the material examined contained more fruits with 4 and 3 locules and less fruits with 2 or 1 locules than it would have contained if the sample had been taken from the whole branch. Position of fruits and flower clusters with different number of locules was followed on one of the branches examined. Each of the first 20 fruits at the bottom of the branch had 4 locules, the next 10 fruits had 3 locules, the following 10 had 2 locules, and the last 20 were single flowers.

Fruits of the population GTY-74862 in which the ovules were examined contained, as an average for 5 plants 1.2% of fruits with 1 locule, 20.0% of fruits with 2 locules, 57.2% of fruits with 3 locules, and 21.6% of fruits with 4 locules (table 11).

The seeds tested for germination had lower number of locules because the seed samples were taken from all seeds harvested from the plant. These seed samples contained, as an average for 5 plants, 1.8% of fruits with 1 locule, 60.2% of fruits with 2 locules, 33.3% of fruits with 3 locules, and only 4.7% of fruits with 4 locules (table 11).

Examination of ovules showed that 500 multigerm fruits taken from 5 plants contained 1496 ovules of which 752 (50.27%) were unfertilized, 553 (36.97%) were fertilized and normally developed, and 191 (12.76%) fertilized, but aborted (table 10 and 11).

Percent of unfertilized ovules increased with the augmentation of the number of locules (or ovules) per fruit. Fruits containing only 1 locule were not taken into consideration because of their low number. Percent of unfertilized ovules (average for 5 plants) varied from 45.0 in fruits with 2 ovules, to 48.2 in fruits with 3 ovules, and to 56.0 in fruits containing 4 locules (table 11).

Table 9 ... Percent of unfertilized, fertilized normal and aborted ovules, and germination percent in 2n monogerm fruits of 5 plants in 64-202 2n monogerm pollinator.

Plants No.	Ovules-100 per plant		Germination per 100 fruits	Sprouts Obtained
	Unferti- lized	Fertilized Normal Aborted		
64-202-4	40	44 16	95.5	95.5
64-202-7	35	59 6	82.0	82.0
64-202-16	20	77 3	96.5	96.5
64-202-21	4	91 5	94.5	94.5
64-202-35	12	87 1	94.5	94.5
Mean	22.20	71.60 6.20	92.60	92.60

Table 10... Number and percent of unfertilized, fertilized normal, and aborted ovules in fruits with different number of locules, and germination of fruits in 5 plants of population GTY-74862 - 4n multigerm

Analysis of ovules in 100 fruits per plant										Germination test of 100 fruits per plant									
Plant No.	Locules per fruit	Fruits with corresponding number of locules	Total		Ovules				Locules per fruit	Fruits with corresponding no of locules	Total number of locules	Germination of 100 fruits							
			number	or ovules	Unfertilized	Fertilized	Normal	Aborted				number	percent	number	percent				
11	1	6	6	0	0	0	0	1	3.0	3.0	3.0	2.0	2.0						
	2	4	8	0	0	0	0	2	60.5	121.0	41.5	51.0	51.0						
	3	58	174	80	72	22	22	3	34.5	103.5	27.0	41.0	41.0						
	4	32	128	98	30	0	0	4	2.0	8.0	1.5	3.5	3.5						
	Total number percent	100	316	192	102	22	22	6.96	100.0	235.5	72.0	97.5	41.40						
12	1	-	-	-	-	-	-	1	2.0	2.0	2.0	2.0	2.0						
	2	44	88	46	38	4	4	2	61.0	122.0	56.5	64.5	64.5						
	3	54	162	110	46	6	6	3	33.5	100.5	27.0	48.0	48.0						
	4	2	8	8	0	0	0	4	3.5	14.0	3.0	5.5	5.5						
	Total number percent	100	258	164	84	10	10	3.87	100	238.5	88.5	120.0	50.31						
13	1	-	-	-	-	-	-	1	3.5	3.5	3.5	2.0	2.0						
	2	36	72	14	44	14	14	2	87.5	175.0	72.0	93.5	93.5						
	3	44	132	62	51	19	19	3	7.5	22.5	6.5	13.0	13.0						
	4	20	80	52	18	10	10	4	1.5	6.0	1.5	3.0	3.0						
	Total number percent	100	284	128	113	43	43	15.14	100	207.0	82.0	111.5	53.86						
14	1	-	-	-	-	-	-	1	-	-	-	-	-						
	2	4	8	6	0	2	2	2	48.0	96.0	33.5	40.0	40.0						
	3	56	168	86	62	20	20	3	38.0	114.0	33.0	49.0	49.0						
	4	40	160	70	58	30	30	4	14.0	56.0	13.0	24.0	24.0						
	Total number percent	100	336	162	120	54	54	16.07	100	266.0	79.0	113.0	42.48						
15	1	-	-	-	-	-	-	1	-0.5	-0.5	-	-	-						
	2	12	24	16	4	4	4	2	44.0	88.0	39.5	46.5	46.5						
	3	74	222	76	104	42	42	3	53.0	159.0	35.0	47.0	47.0						
	4	14	56	14	26	16	16	4	2.5	10.0	2.5	4.5	4.5						
	Total number percent	100	302	106	134	62	62	20.53	100	257.5	77.0	98.0	38.06						
Grand total for 5 plants - number		500	1496	752	553	191	191		500	1204.5	399.0	540.0	540.0						
Percent		100	100.00	50.27	36.97	12.76	12.76		100	100.00	79.8	44.83	44.83						

540.0 - 1.08
500

Table 11.... Average for 5 plants number and percent of unfertilized, fertilized normal and aborted ovules in fruits with different number of locules in population GTY-74862 4n multigerm

Plant No.	Analysis of ovules in 100 fruits per plant				Germination test of 100 fruits per plant				Germination of 100 fruits		
	Locules per fruit	Fruits with corresponding number of locules	Total number of locules or ovules	Total	Ovules		Locules per fruit	Fruits with corresponding number of locules	Total number of locules	Fruits germinated	Sprouts obtained
					Unfertilized	Fertilized					
	Number & percent	number	number	number	Normal	Aborted	Number & percent	number	number	number	number
11, 12,	1	number 1.20	1.20	1.20			1	1.80	1.80	1.20	1.20
13, 14		percent		1.20						66.67	66.67
& 15	2	number 20.00	40.00	18.00	17.20	4.80	2	60.20	120.40	48.60	59.10
		percent		45.00	43.00	12.00				80.73	49.09
	3	number 57.20	171.60	82.80	67.00	21.80	3	33.30	99.90	25.70	39.60
		percent		48.25	39.04	12.70				77.18	39.64
	4	number 21.60	86.40	48.40	26.40	11.60	4	4.70	18.80	4.30	8.10
		percent		56.02	30.56	13.43				91.49	43.09
Total	number	100.00	299.20	150.40	110.60	38.29		100.00	240.90	79.80	108.00
	percent	100.00	100.00	50.27	36.97	12.76		100.00	100.00	79.80	$\frac{108.0}{100} = 44.83$

Percent of fertilized normally developed ovules, on the contrary, was the highest in the fruits with 2 locules (43.0) and declined in the fruits with 3 locules to 39.0, and to 30.5 in fruits with 4 locules (table 11).

Percent of fertilized but aborted ovules was low and very close for all fruits, regardless of the number of locules per fruit. These percentages were 12.0, 12.7 and 13.42 in fruits with 2, 3, and 4 locules respectively (table 11).

Examination of ovules revealed an important observation that sterility of many locules in the fruits of the multigerm tetraploid population was caused by the absence of fertilization, not by the abortion of fertilized ovules.

Germination test included 500 fruits from 5 examined plants. Of this quantity, 399, or 79.80% of fruits germinated. The 500 fruits exposed to germination contained 1204.6 locules, but only 540 (44.83%) sprouts were obtained from them (table 10). No germination was obtained from 55.17% of locules. Germination of multigerm tetraploid fruits was low : 540 sprouts were obtained from 500 fruits. This indicates that only 1.08 locule germinated per fruit. In the sample of multigerm seeds, which contained 99 percent of fruits with 2 and 3 locules, germinated only 1 locule per fruit.

Data for fruit germination coincided very closely with the data obtained from the analysis of ovules. Five hundred examined fruits contained 50.27% unfertilized ovules (of locules), and 110.6 or 36.97% fertilized and normally developed ovules. Germination test showed that 108.0 locules, or 44.83% of them germinated (table 10). This means that percent of germination of the examined tetraploid multigerm fruits was determined by the amount of normally developed ovules; low percent of germination of fruits was due to a high percent of unfertilized ovules. The abortion of ovules played a very insignificant role in the low germination of tetraploid fruits.

In the fruits with different number of locules, percent of germination varied with the tendency for better germination of fruits with higher number of locules. In the fruit with 1, 2, 3 and 4 locules, percent of germinated fruits ranged from 66.67 to 80.73, to 77.18, and to 91.49 respectively. Augmentation of the number of locules tended to increase the percent of germinated fruits.

At the same time percent of obtained sprouts was the highest in the fruits with 1 locule (66.6). In fruits with the higher number of locules (2, 3 and 4), percent of sprouts decreased with some variations, from 49.0 to 39.6 and 43.0, respectively (table 11).

In the second tetraploid multigerm population, 64-2T1, ovules were examined in 3 plants. Three hundred fruits of 3 plants contained 674 ovules of which 260, or 38.58%, remained unfertilized, 350, or 48.96%, were fertilized and normally developed, and 84.00 or 12.46% were aborted (table 12, 13).

The average percent of unfertilized ovules for 3 plants was a little higher in the fruits with 3 locules (40.5) than in fruits with 2 locules (37.6). Percent of fertilized and normally developed ovules was, on the contrary, higher (52.21) in fruits with 2 locules than in fruits with 3 locules (42.34), and percent of aborted ovules was a little higher in fruits with 3 locules (17.11) than in fruits with 2 locules (10.17) (table 13).

In the tetraploid multigerm population, 64-2T1, was observed the same general appearance as in the tetraploid multigerm population of GTY-74862. Namely, that sterility of many locules was caused by a high percent of unfertilized ovules, not by the abortion of ovules. Population GTY-74862 had an average of 50.27 of unfertilized ovules and population 64-2T1 had an average of 38.58%. Percent of aborted ovules was low and close in both populations: 12.76 in GTY-74862 and 12.46 in 64-2T1. (Tables 10, 11, 12, 13.)

Three hundred fruits of the plants examined were tested for germination. Of these germinated 248, or 82.67% of fruits. The germinated 300 fruits contained 615.5 locules of which 317.5 germinated (51.58%) (table 12). The average number of locules for 3 plants equaled 205.16 and 105.8 sprouts was obtained from them (51.58%) (table 13).

As in the tetraploid population of GTY-74862, germination of fruits was low in the tetraploid multigerm population of 64-2T1. Only 51.58% of locules germinated, while 48.42% of locules were sterile; 317.5 (av.) sprouts were obtained from 300 fruits. It means that only 1.06 locule germinated per fruit.

Comparison of data obtained from the analysis of ovules with the data for germination indicate that percent of germinated locules (51.58) is determined by the percent of normally developed ovules (48.96 of ovules per 3 plants).

Percent of germinated fruits raised with the augmentation of the number of locules per fruit. This tendency was expressed very clearly in the population 64-2T1. In fruits with 1,2,3, and 4 locules the percent of germinated fruits raised from 71.4 to 82.1 to 92.8 and to 100, respectively (table 13). At the same time, percent of sprouts produced declined with the augmentation of the number of locules per fruit. In fruits with 1,2,3, and 4 locules, percent of produced sprouts varied from 71.4 to 52.3, to 44.0, and to 35.0, respectively (table 13). Such

Table 12 ... Number and percent of unfertilized, fertilized normal and aborted ovules in fruits with different number of locules, and germination of fruits in 3 plants of population 64-211 - 4n multigerm.

Plant No.	Analysis of ovules in 100 fruits per plant					Germination test of 100 fruits per plant					Germination of 100 fruits	
	Locules per fruit	Fruits with corresponding number of locules		Ovules		Locules per fruit	Fruits with corresponding number of locules	Number & percent	Total number of locules	Fruits germinated	Sprouts obtained	
		number	Unfertilized	Fertilized Normal	Aborted							
21	1	-	-	-	-	1	-	-	-	-	-	-
2	84	168	58	104	6	2	97.5	195.00	89.5	131.5		
3	16	48	18	30	0	3	2.0	6.0	2.0	4.0		
4	-	-	-	-	-	4	0.5	2.0	0.5	0.5		
Total number percent	100	216	76	134	6		100.0	203.0	92.0	136.0		
	100	100	35.19	62.04	2.77		100.0	100.0	92.0	67.0		
22	1	-	-	-	-	1	3.0	3.0	2.0	2.0		
2	86	172	80	80	12	2	96.5	193.0	72.5	78.0		
3	14	42	26	16	0	3	0.5	1.5	0.5	1.0		
4	-	-	-	-	-	4	-	-	-	-		
Total number percent	100	214	106	96	12		100.0	197.5	75.0	81.0		
	100	100	49.53	44.86	5.61		100.0	100.0	75.0	41.0		
23	1	-	-	-	-	1	0.5	0.5	0.5	0.5		
2	56	112	32	52	28	2	86.0	172.0	68.0	83.5		
3	44	132	46	48	38	3	11.5	34.5	10.5	13.5		
4	-	-	-	-	-	4	2.0	8.0	2.0	3.0		
Total number percent	100	244	78	100	66		100.0	215.0	81.0	100.5		
	100	100	31.97	40.98	27.05		100.0	100.0	81.0	46.7		
Grand total for 3 plants - number	300	674	260	330	84		300	615.5	248.0	317.5		
percent	100	100.0	38.58	48.96	12.46		100.0	100.0	82.67	51.58	317.5	1.06

Table 13... Average for 3 plants number and percent of unfertilized, fertilized normal, and aborted ovules in fruits with different number of locules in population 64-2T1 - 4n multigerm

Plant No.	Analysis of ovules in 100 fruits per plant				Germination test of 100 fruits per plant				Germination of 100 fruits	
	Locules per fruit	Fruits with corresponding number of locules	Total Number of locules or ovules	Ovules		Locules corresponding number of locules	Fruits with corresponding number of locules	Total number of locules	Fruits germinated number	Sprouts Obtained number
				Unfertilized	Fertilized Normal Aborted					
21, 22 & 23	1	number				1	1.17	1.17	0.83	0.83
		percent							71.42	71.42
2	number	75.33	150.67	56.67	78.67	15.33	2	93.33	76.67	97.67
	percent			37.61	52.21	10.18			82.14	52.32
3	number	24.67	74.00	30.00	31.33	12.67	3	4.67	4.33	6.17
	percent			40.54	42.34	17.12			92.86	44.05
4	number						4	0.83	0.83	1.17
	percent								100.00	35.00
Total	number	100.00	224.67	86.67	110.00	28.00		100.00	82.67	105.83
	percent	100.00	100.00	38.58	48.96	12.46		100.00	82.67	51.58
									105.83 100 -	
									1.06	

decline in germination of locules was obviously caused by the increased percent of unfertilized ovules in fruits containing many locules (or ovules). Probably the insufficient nutrition for normal development of many ovules in the multigerm fruit caused this appearance.

CONCLUSION AND DISCUSSION

A crossing barrier, which prevents production of triploid seeds in some plant species (Hordeum vulgare (barley), Oenothera Lamarkiana, Datura, Secale cereale (rye), by hybridization of diploids with tetraploids, is absent in Beta vulgaris. Seed setting in male-sterile diploid plants pollinated by tetraploids was abundant.

Percent of unfertilized ovules in the monogerm male-sterile populations of 569-H3 was low and did not differ when male-sterile plants were pollinated by the diploids or by tetraploids.

In all male-sterile populations pollinated by diploids or by tetraploids, percent of fertilized and normally developed ovules was high, although a little lower in the triploid than in the diploid fruits (78%-82% in 2n fruits and 76% in 3n fruits). In the monogerm beets, which are always used as a female parent, flowers containing unfertilized ovules do not develop a fruit and are lost in the process of seed threshing and cleaning. Therefore, the decline in germination may be caused by the incomplete development of fertilized ovules only.

Aborted ovules were found, in a low proportion, in all diploid male-sterile and self sterile populations as well as in tetraploid populations. Their percent was too low in the diploid fruits (4.2 to 8.2), in the triploid fruits (10.2), and in the tetraploid fruits (12.46 to 12.76) to cause a significant decline in germination. Germination of 2n fruits harvested from male-sterile plants was high (82-87%), germination of 3n fruits was lower (50%). Percent of germinated 3n fruits was lower than expected considering the number of normally developed ovules in 3n fruits. A small number of plants examined which produced triploid fruits (only 5 plants in 1 male-sterile line) does not permit to draw a final conclusion. A further study of ovules development in 3n fruits and verification of their germination ability is desirable on a larger material. However the data obtained gave some indications concerning one way to improve the triploid fruits.

In all male-sterile populations the plants were not uniform. They varied in percent of normal and aborted ovules and in percent of fruit germination. These differences between the plants in the populations were significant. Among 5 male-sterile plants which were pollinated by tetraploids and produced triploids fruit, some plants showed a low percent of aborted and a high percent of normal ovules, but 1 plant had a high percent (21) of aborted ovules, a lower percent of normal ovules, and a low germination percent (10). All male-sterile plants were pollinated by a "random sample" of pollen of tetraploid populations. Differences

manifested by the individual male-sterile plants could not be attributed to the tetraploid pollinator alone, but may result in part from the male-sterile plants themselves. These differences are rather of genetical nature than caused by the environment, although the grade of influence of each of these factors is not clear at present.

The male-sterile lines should be studied in respect to their female fertility. It is highly possible that male-sterile lines differ in production of high quality seeds even when pollinated by the diploids (2n seeds). A study and improvement of male-sterile lines in this direction may improve the quality of diploid and triploid monogerm seeds. Probably the use of male-sterile hybrids as female parents for production of 3 way diploid or triploid hybrid seeds will give better results. Whether triploidy is a new factor in the development and germination of sugarbeet seeds and how big is the influence of this factor is difficult to tell at the present stage of our knowledge. Different male-sterile lines should be tested for hybridization with tetraploids in obtaining triploid seeds.

The tetraploid multigerm population of GTY-74862 and the population of 64-2T1 differed very much from the monogerm populations by a high percent of unfertilized ovules (50 and 38) and by a lower percent of normally developed ovules (36 and 42). Percent of aborted ovules was practically the same.

Although percents of fruit germination seems to be high enough in the tetraploid multigerm populations (79% and 82%), the veritable germination of tetraploid multigerm fruits was low. Only 1.08% sprouts of locules per a multigerm fruit germinated in the population GTY-74862 and 1.06% sprouts or locules per a multigerm fruit germinated in the population 64-2T1. A low germination of tetraploid multigerm fruits was conditioned by the high percent of unfertilized ovules, which caused sterility of many locules, but not by the abortion of fertilized ovules.

Whether a low percent of fertilization in tetraploid multigerm populations is caused by the sterility of gametes resulting from irregularities in meiosis, or by some other reason should be determined by the further investigations.

A close agreement between 2 tetraploid multigerm populations indicates with a high degree of probability that the sterility of locules caused by a high percent of unfertilized ovules is a general peculiarity of the tetraploid multigerm fruits.

Percent of germinated multigerm fruits increased in both populations proportionally with the augmentation of the number of locules per fruit. A higher number of locules provided for more chances for germination of at least 1 sprout per fruit. On the contrary, the percent of sprouts increased proportionally with the decrease of the number of locules.

Germination of the tetraploid multigerm fruits was low in comparison with the germination of monogerm fruits. In monogerm plants with 85-92% of fruit germination there was also germination from 85-92% of the locules, while in the multigerm tetraploid population only 44% and 51% of locules produced sprouts. To what degree such low percent of locule germination in the tetraploid populations was conditioned by tetraploidy or by the multigermity will need further investigation. At present the data obtained indicate that the single germ of monogerm fruits has a better condition for development than the several germs in a multigerm fruit.

The experiments described are a first step in the study of viability of diploid, triploid, and tetraploid sugarbeet fruits. The material examined is not sufficient to justify final conclusion concerning the viability of triploid fruits. The experiments show that female parent (male-sterile line), as well as the tetraploid pollinator, is also responsible for the quality of the produced triploid seeds. Investigation disclosed the nature of the low fruit germination in the tetraploid multigerm populations as well as the effect of different number of locules in the multigerm fruit on the development of ovules and on germination of fruits.

The method applied--a combined study of development of ovules and of germination of fruits--appeared to be a useful method in investigation of this problem.

P A R T VIII

BREEDING FOR YELLOWS RESISTANCE^{1/}

- - - - -

VIRUS YELLOWS INVESTIGATIONS^{2/}

Foundation Project 12

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^{1/} Field test at Davis, California, conducted in cooperation with the California Agricultural Experiment Station.

^{2/} Investigations supported in part by funds received from the California Beet Growers Association, Limited, under Cooperative Agreement.

PROGRESS IN BREEDING FOR YELLOWS RESISTANCE^{1/}

J. S. McFarlane, C. W. Bennett, I. O. Skoyen, and R. J. Hecker

The low correlation between loss in root yield and freedom from yellowing complicates the job of breeding for yellows resistance. Plants which remain green following inoculation with yellows are often damaged more severely than are those which turn yellow. Selections are made from plants inoculated with yellows and are based primarily on root size. The selections must then be evaluated by comparing the performance of inoculated and noninoculated plants. To obtain an accurate evaluation it is essential that the noninoculated plots be maintained free of yellows infection. Aphid populations remain high throughout the entire growing season at Salinas and accurate tests cannot be made. In the Central Valley, aphid populations usually drop to a low level during the late spring, so arrangements have been made with the University of California to conduct the tests on the Agronomy farm at Davis.

Plans and Procedures

Evaluation tests were planted at Davis, California, May 20. One test was designed to determine the resistance of selections from the yellows breeding program at Salinas. This test also included the parental lines from which the selections had been made, a tetraploid line, and a yellows-resistant selection from The Netherlands.

A second test, consisting of nine three-way hybrids and five single-cross hybrids, was planted to determine their yellows resistance. A third test, consisting of 16 inbreds, was also planted. This test included seven multigerm inbreds and two monogerm inbreds which had been selected for yellows resistance. Nonselected inbreds commonly used as parents in hybrid varieties were also tested.

A similar design was used in all tests. The variety subplots were two rows wide by 42 feet long and were replicated five times. Stand counts were made following thinning and plant populations were adjusted so that a similar number of plants remained in the inoculated and noninoculated plots of any given variety in each replication. Inoculations were made July 7 with virulent strains of beet yellows and beet western yellows viruses. Ratings for yellowing and stunting were made September 15. Beet harvest was started October 27 and completed November 18.

^{1/} The assistance of Dr. F. J. Hills of the University of California in arranging and caring for the tests is gratefully acknowledged.

Selections for yellows resistance were made at Salinas from beets planted March 6, April 13, and July 10. The plants were thinned to a spacing of 24-30 inches to reduce competition between plants. The March planting was inoculated April 30, the April planting, June 4, and the July planting, August 14, with a combination of beet and western yellows viruses. Aphid populations were high and natural infection with mosaic and yellows occurred prior to inoculation in both plantings.

The March and April plantings included both open-pollinated and inbred lines which had been selected for yellows resistance in previous years. Several unselected monogerm lines were also included. The July planting was from seed of yellows-resistant lines selected at Salinas in 1963.

Results

Good stands were obtained with nearly all entries in the Davis tests and all inoculated plots showed a high level of virus infection. Very little infection occurred in the noninoculated plots until late in the season. This late infection had little, if any, effect on yield and probably did not greatly affect the sucrose percentage of the non-inoculated plots. The nitrogen level in the test area was high and yellowing tended to be masked. Selections which had been made in the field for yellows resistance tended to be less yellow than were the unselected lines. Mild yellows symptoms were especially evident in many of the inbred selections. Root yields were high for the relatively short five-month growing season. Sucrose percentages were low.

The combination of beet and western yellows caused root-yield losses ranging from 13.9 to 41.7 percent and sucrose losses ranging from 1.1 to 1.7 percentage points among open-pollinated varieties and selections (table 1). The selection 313 showed only about one-third as much damage as did the US 75 variety from which it had been selected. However, the results of this test indicate that a significant reduction in both root yield and sucrose percentage occurred in this selection. A sister selection 330 showed about two-thirds as great a loss as did US 75 and was not significantly different from US 75 in yield and sucrose percentage.

The selections 321 and 337 failed to show a significant improvement in yellows resistance over the parent lines from which they had been selected. The tetraploid of 663 showed significantly less damage from yellows than did diploid 663. The selection 338 showed a significant improvement in both yellows resistance and root yield over the parent variety F57-85. The selection 234 developed by the Instituut voor Rationele Suikerproductie in The Netherlands performed very well from the standpoint of yield and sucrose percentage and was similar to the better US 75 selections in yellows resistance.

Table 1. Reduction in yield and sucrose percentage of yellows-resistant selections and of unselected lines when inoculated with a combination of beet and western yellows viruses at Davis, California, in 1964.

Variety	Description	Performance of Check		Loss from Yellows	
		Root Yield	Sucrose	Root Yield	Sucrose
		Tons/Acre	Percent	Percent	Percentage Points
313	5th suc. YRS US 75	25.6	12.3	13.9	1.1
330	5th suc. YRS US 75	27.7	12.8	21.6	1.2
011	4th suc. YRS US 75	26.7	13.5	26.1	1.4
12DR7-C	Fife's YRS US 75	29.0	12.7	41.7	1.4
368	US 75	28.2	13.3	37.2	1.7
321	3rd suc. YRS 671	26.7	12.6	30.7	1.2
671	Type 0 line	25.1	13.1	36.8	1.3
337	YRS 663	31.2	13.1	39.1	1.4
663	Top cross parent	30.0	13.1	38.5	1.1
F62-63T	663 (Tetra)	33.1	11.9	30.3	1.2
338	YRS F57-85	23.3	13.8	31.9	1.4
F57-85	Type 0 US 75	20.3	13.7	40.0	1.7
234	YRS from Rietberg	28.2	13.7	18.4	1.3
LSD (5%)		1.8	0.7	6.4	NS

Table 2. Reduction in yield of sugarbeet hybrids when inoculated with a combination of beet and western yellows viruses at Davis, California, in 1964.

Variety	Description	Acre Root Yield		Loss from Yellows Percent	
		Check	Inoculated		
		Tons	Plots Tons		
<u>Three-way hybrids</u>					
3539H8	(562H0 x 546) x NB7	26.0	19.4	24.7	
263TH4	(562H0 x 569) x 663 (Tetra)	32.1	23.3	26.1	
3539H1	(515H0 x 569) x NB7	29.6	21.4	27.7	
3425H4	(562H0 x 569) x 3425	31.0	21.8	29.3	
3539H4	(562H0 x 569) x NB7 (Tetra)	23.8	16.5	30.5	
363HE	(562H0 x 546) x 663	31.9	21.8	31.8	
363H4	(562H0 x 569) x 663	31.0	20.5	33.5	
3534H4	(562H0 x 569) x NB7	31.1	20.5	33.8	
163HE	(MS of NB1 x NB5) x 663	32.6	21.4	34.3	
LSD (5%)		3.0	2.9	NS	
<u>Single-cross hybrids</u>					
F63-546H3	562H0 x 546	25.6	18.7	26.6	
F63-569H3	562H0 x 569	22.8	16.2	29.0	
F63-546H4	563H0 x 546	24.6	17.3	29.8	
3550H4	563H0 x 550	24.4	16.7	31.3	
F63-569H4	563H0 x 569	23.5	16.1	32.0	
LSD (5%)		NS	NS	NS	

Root-yield losses from yellows among nine three-way hybrid varieties ranged from 24.7 to 34.3 percent (table 2). Losses among five male-sterile, single-cross hybrids ranged from 26.6 to 32.0 percent. Differences in losses from yellows among the hybrids were not significant.

Root-yield losses ranged from 7.6 to 41.1 percent among inbred lines selected for yellows resistance and from 22.0 to 60.6 percent among unselected inbreds (table 3). The most resistant inbred, 3742, showed only a 7.6 percent loss from yellows and also had a very satisfactory yield and sucrose percentage. The most susceptible inbred in the test, 3511, had been selected at Salinas on the basis of severe stunting and yellowing. This inbred not only suffered a 60.6 percent yield loss from yellows but also performed very poorly in the non-inoculated plots. Apparently, selection had been made for other deleterious characters in addition to yellows susceptibility.

Selections based both on freedom from yellowing and root size were made from March, April, and July plantings at Salinas. A total of 420 roots were selected from twelve segregating populations grown on 1.5 acres in the March and April plantings. A total of 740 roots were selected from 18 segregating populations grown on 1.8 acres in the July planting.

Discussion and Conclusions

Results of the 1964 yellows-resistance evaluation tests provide additional evidence that improvements in resistance can be made by selecting in the field on the basis of root size and freedom from yellows symptoms. The most striking gains were observed in selections from US 75. As might be expected, a reduction in sucrose percentage accompanied the gain in yellows resistance in some selections. This trend was particularly evident in selection 313 which was one percentage point lower in sucrose content than was the parent US 75. Not all selections showed the tendency to lower sucrose percentage.

Inbred lines have proved to be more difficult to evaluate for resistance than open-pollinated selections and hybrids. This is particularly true when plantings are made under high temperature conditions, as is done at Davis. Difficulties occur with stands and with losses from root rot. Variability caused by these difficulties contribute to a high experimental error (table 3). In spite of these problems, results with inbreds have been most encouraging and it is anticipated that hybrid combinations can be developed with greatly improved resistance.

In the 1964 tests, as well as in earlier tests, improvement in resistance was expressed primarily as an improvement in root yield. Losses in sucrose occur in all selections and rarely is there a significant difference among the entries with respect to the sucrose loss.

Table 3. Reduction in yield and sucrose percentage of sugarbeet inbreds when inoculated with a combination of beet and western yellows viruses at Davis, California, in 1964.

Variety	Description	Performance of Check		Loss from Yellows	
		Root Yield	Sucrose	Root Yield	Sucrose
		Tons/Acre	Percent	Percent	Points
3742 ₁ /	YRS 928-9 x 5502	18.6	13.0	7.6	1.0
3754 ₁ /	YRS 671-22 x 9716-10	15.4	11.5	13.3	1.0
3740	YRS 928-3 x 5502	18.5	12.4	15.1	1.0
3757 ₁ /	YRS 911 x 9716-4	18.7	11.0	17.6	0.9
3743 ₁ /	YRS 928-20 x 9561-3	16.3	13.3	20.2	1.0
3753 ₁ /	YRS 671 x 9716-4	21.2	10.8	24.1	0.7
3747	YRS 928-29 x 5577-2	21.6	12.7	26.2	1.1
3768	YRS 926-36 x 9716-8	21.9	12.7	28.6	1.7
3763	YRS 8583 mm inbred	22.0	13.1	41.1	0.7
F63-563	mm inbred	9.2	--	22.0	--
3534	mm inbred	12.5	--	25.6	--
3550	mm inbred	20.9	--	28.3	--
F58-502H0	MS of NBL	19.2	12.8	32.6	1.7
0539	NB7	18.9	11.0	32.6	0.9
F62-546	mm inbred	20.4	--	34.4	--
F59-569	mm inbred	17.4	--	38.4	--
3511	Yellows susc. sel. NB2	4.2	--	60.6	--
LSD (5%)		2.9	0.6	12.6	NS

₁/ Replicated two times, not included in statistical analysis.

Even though inoculations are made with the same virus strains on plants of approximately the same age, damage to any given variety may vary considerably from one year to another. Results of four years testing with US 75 and with O11, a yellows-resistant selection from US 75, indicate that this variation in damage does not necessarily affect the comparative resistance ratings of the varieties. Yield losses in US 75 have been 42, 43, 50, and 37 percent for the years 1961-64, respectively. Corresponding losses for O11 have been 24, 29, 38, and 26 percent.

Hybrid combinations utilizing 313, 330, and 337 as the pollen parents are being included in 1964-65 variety tests. Hybrids have been produced between a male-sterile line and the yellows-resistant inbreds 3716, 3753, 3754, and 3757. Backcrosses will be made to the inbred lines and yellows-resistant male-sterile lines developed. To date, higher resistance has been obtained in multigerm inbreds than in monogerm inbreds. Emphasis is being placed on the development of yellows-resistant monogerm inbreds and their male-sterile equivalents.

RESULTS OF 1964 FIELD TEST AND A SUMMARY OF THE PERFORMANCE OF TWO PROMISING SELECTIONS MADE ON THE BASIS OF A COMBINATION OF ROOT WEIGHT AND THE AMINO ACID PATTERN IN MATURE INFECTED LEAVES FOR POSSIBLE RESISTANCE TO BEET YELLOWS

by

J. M. Fife

Investigations have shown that the amino acid pattern is greatly altered in the mature leaves of sugarbeet plants showing the chronic symptoms of beet yellows and of western beet yellows. In view of these findings, individual plants were selected, from a large population of beet yellows-inoculated plants, on the basis of their root weight and on the amino acid pattern in their mature leaves showing the chronic symptoms of the disease. The methods used in making the selections have been described in detail in the 1960 report. A second selection has been made and also a seed increase. This report gives the results of the 1964 field test, which includes both the first and a second selection. The report also summarizes the performance of two selections, one of which has been field tested five years, while the other selection has been tested four years.

METHODS

A second selection was made, as follows: Plants of the 28 selections, made on the basis of a superior root weight and a greater than the mean amino acid ratio, and plants of 10 selections, made on the basis of a superior amino acid ratio and a greater than the mean root weight, made up the population from which the second selection was made. The methods used in obtaining these 38 selections are reported in detail in the 1960 report.

Twenty-four plants of each of the above 38 selections, together with plants of US 75, were grown in the greenhouse. The plants were inoculated in the early 4-leaf stage with a virulent strain of the beet yellows virus. When the plants had reached the chronic stage of the disease, at about the sixth week, the two youngest mature leaves showing the chronic symptoms of the disease, were removed from each plant for the determination of the concentration of aspartic acid, glutamic acid and glutamine $\frac{1}{2}$. The plants were allowed to grow 120 days from emergence before the roots were harvested and weighed. The amino acids were determined on each individual plant.

Those plants having both a superior root weight and also a superior amino acid ratio were selected.

$\frac{1}{2}$ The amino acid spot labeled citrulline in earlier papers and reports, has been shown by further investigations to be made up mainly of glutamine, not citrulline. Although alanine and citrulline have been demonstrated to be present, the concentration of these two amino acids are insignificant in view of the small volumes of leaf juice used to spot the papers. The corrected amino acid ratio $\frac{\text{aspartic} + \text{glutamic}}{\text{glutamine}}$ will

be used in this and future reports. The same individual plants would have been selected regardless of what the amino acid spot on the paper-gram was labeled.

A root weight (or amino acid ratio) was considered to be superior if it exceeded the mean root weight of the total population by at least twice the standard deviation. Only 10 plants, of a population of approximately 1000, were found to meet the above requirements. These plants, after adequate thermal induction, were placed in isolation for an open-pollinated seed increase. The seed from each individual plant was harvested individually and each seed lot considered a selection.

These 10 selections were tested in the greenhouse and in the observation plot in the field, using a virulent strain of the beet yellows virus to inoculate each plant. From 6 to 10 plants of each of the 5 selections showing the most promise of being superior, in the preliminary tests, were isolated for a seed increase. A total of 36 plants made up the group for the seed increase. The seed from these plants was composited. A successive seed increase was also made. The above selection (second) and a seed increase from it were included in the 1964 test.

The test was carried out adjacent to the regular planting of a plot test conducted by McFarlane, Bennett, and Skoyen. The agronomic operations and agricultural practices were the same except for the experimental design. The information pertinent to this test is given below.

Location: Spence Field of the U. S. Agricultural Research Station.

Fertilizer applied: 650 lbs. of 10-10-5 preplant. June 15, 200 lbs. ammonium sulfate per acre.

Planting date: April 17.

Thinning date: May 22.

Disease treatment: Plants inoculated June 4, with a virulent strain of the beet yellows virus (strain 5) 35 days after emergence.

Harvest date: October 7. Total growing period from emergence 176 days from emergence.

Irrigation: Sprinkler irrigation, as required until July 9, then furrow irrigation until harvest.

Diseases: By thinning time, practically 100 percent of the plants showed symptoms of yellows. Strains of the beet western yellows virus may have predominated, but due to the presence of sugarbeets growing in the field when the plants emerged, the beet seedlings could also have carried strains of the beet yellows virus as well.

Insects: One infestation of leaf miners in early June. Plot was sprayed to control further damage.

Experimental design: 7 X 7 latin square, two-row plots 40 feet long, rows 28 inches apart.

Sugar analysis: From two 15-beet samples taken from each plot and run in duplicate.

RESULTS

The results of the 1964 test is summarized in table 1. The plot was located on very uniform soil as shown by the low nonsignificant rep errors. The root yields are somewhat lower than for 1963. This can be accounted for in that this year the plants had a 9-day shorter growing period and by the fact that the plants had only 35 days of growth before being inoculated with the virulent strain of the virus as compared to 70 days of growth for the plants last year. This year the plot also had one infestation of leaf miners.

In this test two selections were outstanding compared to that of the parent. The percentage sucrose in the roots of selection 313-DS3-C was superior to that of the parent, the difference being significant at the one percent level. The acre yield of beets and of sugar were greater than ^{for} the parent but not significantly so.

Selection 123-RS-C (a second selection) showed the most striking performance. This selection was superior to the parent, at the one percent level of significance, in percent sucrose, in tons of beets and in pounds of sugar per acre.

Selection 324-RSC-C is a seed increase of selection 123-RS-C. The performance of the seed increase (324-RSC-C) confirms in a striking way the performance of the selection. The results also show that there was no indication of a regression in either percent sucrose or yield of beets as a result of the seed increase.

At harvest, the degree of yellowing of the plants of the selection was much less than the plants of US 75, figure 1, page 316.

Selection 313-DS3-C, (table 1) is one of the 28 selections made on the basis of a superior root weight and having an amino acid ratio greater than the mean of the population from which the selections were made. This selection (basic code DS3) has been, in certain respects, superior to the parent in each of four years of testing in the field. The performance of this selection, compared to that of the parent, is summarized in table 2.

In the four tests, the percent sucrose in the roots of the selection was superior to the parent US 75. In the 1964 test, the difference was significant at the one percent level. The most striking observation is that the ratio of percent sucrose in roots of the selection to that of the parent remained constant. This is especially noteworthy in view of the range in percentage sucrose found over the four years. This constant ratio, and, coupled with the fact that the 1962, 63, and 64 tests were each conducted with a successive seed increase, is strong evidence that the selection has been stabilized.

Table 1.

Field test of six selections inoculated with a virulent strain of beet yellows virus 35 days after emergence, 1964.

Selection	Acre Yield		Sucrose Percent	Harvest Count Number
	Sugar Pounds	Beets Tons		
US 75 (Parent)	3,138	9.8	16.0	150
313-DS3-C	3,453	10.2	16.9**	151
312-DS23-C	3,257	10.0	16.3	156
313-DS9-C	3,268	10.0	16.3	148
312-DS16-C	2,863	8.9	16.1	146
123-RS-C	3,881**	11.4**	16.9**	144
323-RSC-C	4,139**	12.3**	16.8**	154
General Mean	3,428	10.37	16.5	150
S. E. of Mean	136	0.37	0.20	Beets
L.S.D. (19:1)	390	1.06	0.56	per
S. E. of Mean in % of Mean	4.0	3.6	1.2	100' row

Odds 19:1 $2.030 \times \sqrt{2} \times \text{Standard Error of Mean}$

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES		
		Sugar Pounds	Tons Beets	Percent Sucrose
Between selections	6	1,363,805	9.28	1.04
Between replications	6	135,189	0.78	0.52
Remainder (Error)	36	129,435	0.96	0.27
Total	48			

Calculated F values for selections 10.54** 9.63** 3.83**

** Exceeds the 1% point of significance (F=3.35)

Table 2.

Summary of field tests of selection 313-DS3-C made on the basis of a combination of root weight and the amino acid pattern in the mature leaves of beet yellows-infected plants, (basic code DS3).

Year	Type of Test	Sucrose	Ratio X 100	Beets	Ratio X 100	Sugar	Ratio X 100
		%	<u>DS-3</u> US75	Tons	<u>DS-3</u> US75	Pounds	<u>DS-3</u> US75
1960	Alternating plants in same row <u>1</u> /DS3	13.0*	105				
	Parent (US 75)	12.4					
1962	6 X 6 Latin Square DS3	15.1*	106	11.4	110	3,439*	116
	Parent (US 75)	14.3		10.7		2,953	
1963	6 X 6 Latin Square DS3	13.9*	106	15.0	108	4,163*	114
	Parent (US 75)	13.1		13.9		3,633	
1964	7 X 7 Latin Square DS3	16.9**	106	10.2	104	3,453	110
	Parent (US 75)	16.0		9.8		3,138	

1/ Fifty plants of the selection, each one alternating in the same row with a plant of the parent. The percent sucrose was determined on each individual root.

*,** Exceeds the 5 and one percent point of significance respectively.

The beet yields of the selection, although not superior to that of the parent, were greater than the parent in each of the 4 tests. The ratio of tons of beets of the selection to that of the parent was lower in the 1963 and 1964 tests than in the 1962 test. The late inoculation of the plot in the 1963 test in all probability was responsible for the lower ratio in 1963. In the 1964 test, the heavy infestation of leaf miners may have contributed to the low ratio for that year. In both the 1962 and 1963 tests, the significantly greater percentage sucrose, coupled with greater yields of beets, resulted in significantly more sugar per acre than the parent for both years.

Selection 312-DS23-C (table 1) is also one of the 28 selections made on the basis of a superior root weight and having an amino acid ratio greater than the mean of the population from which the selections were made. This selection (basic code DS23), like its sister, has shown promise of having a certain amount of resistance to beet yellows. The performance of this selection, compared to that of the parent, is summarized in table 3.

There is strong evidence that this selection may also be superior to the parent in percent sucrose when the plants are inoculated in the very early stages of growth. In all five tests, the percentage sucrose was greater than ^{that of} the parent and in two tests the difference was significant. The ratio of percent sucrose of selection to that of the parent, in four of the tests, was slightly higher than the same ratio for selection DS3 (table 2).

In each of the 4 tests, the selection produced a greater tonnage of beets than the parent. The greater yields, however, ^{were} not statistically significant. In two tests the sugar per acre was superior to that of the parent. The first three tests were made with the first seed increase of the selection, while the last two tests were made with the second seed increase.

SUMMARY

Selection 313-DS3-C originated from a single plant and was one of 28 plants which was selected from plants of US 75 inoculated with a virulent strain of the beet yellows virus. Each of these plants had a superior root weight and, in addition, the amino acid ratio was greater than the mean in the mature leaves showing the chronic symptoms of the disease. These 28 plants were isolated for a seed increase. The seed from each plant was harvested separately and each considered a selection. For the fourth year, the above selection was superior to the parent in the percentage sucrose in the roots. Although the yield of beets was not significantly greater than that of the parent, the selection produced a greater tonnage of beets in all three years that yield tests were made. In two of the three years, the sugar per acre produced by the selection was superior to that of the parent. In view of the constant ratio of percent sucrose of the selection to that of the parent, and, coupled with the fact that the 1964 test was conducted with the third successive seed increase, it appears that this selection is stable.

Selection 312-DS23-C has shown in 5 successive years of testing that its performance, relative to that of the parent, is practically the same as that of its sister (selection 313-DS3-C). In every test, the percent sucrose in the roots of the selection was greater than in the roots of the parent (US 75). In 2 tests the difference was significant. In all 4 years in which root yields were determined, the tonnage of beets produced by the selection was greater than that of the parent. These differences were, however, not significant. In two of the four tests, the sugar per acre produced by the selection was superior to that of the parent.

In the 1964 test (table 1) the most striking performance of any of the selections tested was made by a reselection, 123-RS-C, and by a seed increase of this selection, namely 324-RSC-C. Each plant making up this reselection had both a superior root weight and also a superior amino acid ratio in the mature leaves of the beet yellows-infected plant-population from which the plants were selected. The percentage sucrose in the roots, the tons of beets and the sugar produced per acre by this reselection, 123-RS-C, were all superior to US 75 at the one percent level. The almost identical performance of a seed increase (324-RSC-C), made from the above selection, indicates that further testing may show that the reselection may have become stabilized.

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Table 3.

Summary of field tests of selection 312-DS23-C made on the basis of a combination of root weight and the amino acid pattern in the mature leaves of beet yellows-infected plants, (basic code DS23).

Year	Type of Test	Sucrose	Ratio X 100	Beets	Ratio X 100	Sugar	Ratio X 100
		\$	<u>DS23</u> <u>US75</u>	Tons	<u>DS23</u> <u>US75</u>	Lbs.	<u>DS23</u> <u>US75</u>
1960	Alternating plants in same row ^{1/} DS23	13.1*	106				
	Parent (US 75)	12.4					
1961	6 X 6 Latin Square						
	DS23	17.1*	107	17.9	119	6,104*	130
	Parent (US 75)	16.0		15.0		4,702	
1962	6 X 6 Latin Square						
	Only one Rep. DS23	16.1	113	11.6	108	3,730	126
	Parent (US 75)	14.3		10.7		2,953	
1963	6 X 6 Latin Square						
	DS23	13.6	104	14.9	107	4,077*	112
	Parent (US 75)	13.1		13.9		3,633	
1964	7 X 7 Latin Square						
	DS23	16.3	102	10.0	102	3,257	104
	Parent (US 75)	16.0		9.8		3,138	

^{1/} Fifty plants of selection, each plant alternating in the same row with a plant of the parent. The percent sucrose was determined on each individual root.

* Exceeds the 5 percent point of significance.



Figure 1.--Difference in the degree of yellowing and of top growth between plants of US 75 and of a seed increase of a second selection. Both were inoculated in the very early stages of growth with a virulent strain of the beet yellows virus.

FURTHER STUDIES OF BEET YELLOWS AND BEET WESTERN YELLOWS VIRUSES

C. W. Bennett

Introduction

In studies of strains of beet yellows virus (BYV), 6 strains of this virus were described (1). Three of these were severe and caused vein etching or vein clearing on sugarbeet and Chenopodium capitatum. Three were milder and caused no vein clearing on sugarbeet or on C. capitatum. These three strains, however, produced yellowing of mature leaves of beet and reddening of older leaves of C. capitatum. None of the 6 strains was found to infect Capsella bursa-pastoris. After Duffus (3) found that the beet yellows disease in western United States is caused by a complex of at least 2 viruses; namely, beet yellows virus (BYV) and a less virulent virus which is now called beet western yellows virus (BWYV) (4), the question arose as to whether the 3 mild strains of virus considered to be mild strains of BYV might in fact be strains of BWYV capable of infecting C. capitatum.

An extensive series of tests has been made over a period of four years to obtain additional information as to the relationships of the virus strains considered to be mild strains of BYV. In making these tests, comparisons have been made both with virulent strains of BYV and with different isolates of BWYV.

Differential Hosts of the Two Yellowing Viruses

Five species of plants have been used as hosts, in attempts to differentiate BYV from BWYV. Each of these species gives a reaction characteristic of each of the two viruses in cases where known selected isolates of each virus have been used.

Sugarbeet. Virulent strains of BYV begin to produce vein clearing in young leaves in 7-10 days. These leaves usually are dwarfed and show depressed veins on the dorsal side of the leaf. Young leaves produced later show no effects. Mild strains of BYV produce no symptoms on young leaves; mature leaves begin to yellow in about 20 days.

BWYV produces no symptoms on young leaves; older leaves begin to yellow in about 20 to 30 days.

Capsella bursa-pastoris. Shepherd's-Purse. No evidence of infection has been obtained on this species with any virus isolate considered to be BYV.

Older leaves of plants inoculated with isolates of BWYV begin to yellow in about 30 days. The intensity of yellowing varies with the isolate and possibly with other factors.

Chenopodium capitatum. Virulent strains of BYV produce vein clearing and curling of young leaves in 7 to 10 days and older leaves turn red. Plants are dwarfed and may be killed. Less virulent strains produce reddening of older leaves in about 20 days.

No evidence has been obtained that any isolate of BWYV infects this species.

Claytonia perfoliata. All isolates of BYV have produced numerous small necrotic spots on leaves. The spots are more abundant on the distal half of the leaf. Spots usually, but not always, are associated with the production of red pigment.

Isolates of BWYV induce reddening, browning, or yellowing of the distal end of leaves. No discrete spots are produced and the intensity of leaf discoloration varies greatly.

Tetragonia expansa. New Zealand Spinach. Virulent strains of BYV produce vein clearing in young leaves in 7 to 10 days. The vein clearing continues to be produced as long as the plants are growing vigorously. Mild strains produce no symptoms on young leaves, but older leaves begin to turn yellow about 20 days after plants are inoculated.

In tests with isolates of BWYV that have passed through sugarbeet no symptoms have been produced on this species that have been shown to be caused by BWYV.

It will be observed from these descriptions of symptoms that sugarbeet and Claytonia perfoliata are susceptible to both BYV and BWYV, that Chenopodium capitatum and Tetragonia expansa are susceptible only to BYV, and that Capsella bursa-pastoris is susceptible only to BWYV. If these indications are correct, these hosts would serve to differentiate the two viruses regardless of strain. However, it is well known that strains of some viruses, such as strains of curly top virus for example, differ in their host range.

Effectiveness of Differential Hosts in Virus Separation

Over the past 4 years sugarbeet, Capsella bursa-pastoris, Chenopodium capitatum, Claytonia perfoliata, and Tetragonia expansa have been used to determine the types of virus present in beets sent to the U.S. Agricultural Research Station in Salinas, California, for diagnosis. More than 700 plants of this type have been tested and more than 90% of these plants have been shown to have one or both of the yellowing viruses. In all instances where C. capitatum showed symptoms of yellows, the virus was of the BYV type. From this evidence it would appear that this species is solidly immune from all strains of BWYV that infect sugarbeet.

C. bursa-pastoris has shown only different types of yellowing of mature leaves. Incubation period of the virus has been 20 days or more. In all cases where transfers were made from affected C. bursa-pastoris plants to other differential hosts the reactions of these hosts have been those characteristic of those caused by BWYV. This species appears, therefore, to be immune from the isolates of BYV tested.

Tetragonia expansa has shown a certain amount of yellowing of old leaves in some of the tests in which other differential hosts indicated the presence on BWYV only. However, transfers of aphids from 23 of the plants showing yellowing of older leaves, to differential hosts, gave no evidence of infection. Older leaves of noninoculated plants of T. expansa sometimes tend to yellow. It is thought, therefore, that the yellowing of leaves of plants inoculated from BWYV sources, and from which no virus was recovered, probably was of this type. The species, therefore, appears to be immune or highly resistant to all isolates of BWYV that have come from sugarbeet.

Claytonia perfoliata, although it is susceptible to infection with all isolates of both viruses that have been tested, is a good differential host, since strains of the two viruses produce distinctly different symptoms. BYV characteristically produces small necrotic spots and BWYV produces discoloration of the distal ends of the leaves without necrotic spots. Usually, mixtures of the two viruses can be identified from the two types of symptoms on the same leaf.

Combination and Separation of Strains of BYV and BWYV in Sugarbeet

It has been known for a considerable time that a single beet may be infected with both BYV and BWYV and that such combinations frequently occur in the field. In California, plants infected with BYV usually have BWYV. In fact, a single beet plant probably is capable of harboring all of the known viruses of sugarbeet. Individual plants have been experimentally infected with beet yellows virus, beet western yellows virus, cucumber mosaic virus, beet mosaic virus, marble leaf virus, and curly top virus. Probably other viruses could be added to this mixture, if desired.

The combinations of BYV and BWYV listed below have been made in sugarbeet. Names indicate the virus isolate or virus-isolate source used. The virus listed first was introduced first followed by superimposition of the second virus.

BWYV-Longmont, Colo., BYV-Grimes, Calif.
BWYV-Sand Valley, Calif., BYV-Strain 5
BWYV-Salem, Ore., BYV-Strain 5
BYV-Strain 5, BWYV-Salinas, Calif.
BWYV-Salem, Ore., BYV-Strain 1
BYV-Mesa, Ariz., BWYV-Mesa, Ariz.
BWYV-Salem, Ore., BYV-Grimes, Calif.
BWYV-Sand Valley, Calif., BYV-Strain 3

Transfers were made to differential hosts from plants with the above virus combinations. All plants of Chenopodium capitatum and Tetragonia expansa, inoculated from plants with the above-indicated combinations, showed symptoms typical of those produced on these species by BYV. All plants of Capsella bursa-pastoris inoculated from the same plants showed symptoms characteristic of BWYV.

It would appear from these results that strains or isolates of the two viruses may be introduced into the same plant without difficulty and that they may be readily separated by use of differential hosts.

Further Tests of Mild Strains of BYV

Three virus isolates that cause relatively mild symptoms on sugar-beet have been described as mild strains of BYV.(1). Further studies of two of these isolates (strains 1 and 3) and 2 isolates from Colorado have been made in order to obtain further information on their relationship to the more virulent strains of BYV.

BYV and BWYV have distinctly different relationships to the vector Myzus persicae, BYV being lost by the aphid in from 24 to 96 hours (1) and BWYV being retained probably for the life of the insect (3). The earlier tests of properties of BYV were made with virulent strains of this virus, so it seemed desirable to make further tests with the isolates that produced mild symptoms. Tests were made in which aphids were allowed to feed for 24 hours on infected beet plants. The aphids were then transferred to young radish plants, after which they were transferred at 24-hour intervals to plants of Chenopodium capitatum. The results are shown in Table 1.

Table 1. Retention of mild strains of beet yellows virus by the green peach aphid, Myzus persicae.

Virus strain or isolate used	Test plants inoculated and infected by aphids after indicated period on virus-free plant 1/				
	Check ^{2/}	1 day	2 days	3 days	4 days
Colorado 1	5/6	5/6	0/6	0/6	0/6
Colorado 2	2/6	1/6	2/6	2/6	0/6
Strain 1	6/6	1/6	1/6	0/6	0/6
Strain 3	6/6	6/6	1/6	2/5	0/6

1/ Denominator indicates number of plants inoculated; numerator the number of plants infected.

2/ Inoculated with aphids taken directly from diseased beet plant.

The results of these tests (Table 1) indicate a range of variation in period of retention of the isolates tested, but no isolate was retained by the green peach aphid for as long as 4 days. These results are similar to those reported for the more virulent strains of BYV (1).

There is evidence, with strains of certain viruses, that infection and complete invasion by one strain of the virus gives immunity or a high degree of resistance to infection and invasion of the plant by a second strain of the same virus. Hence, resistance of a plant to infection by a second virus has been considered to indicate a relationship between the two viruses.

It was decided, therefore, to test the resistance of plants completely invaded by a mild strain of BYV to infection and invasion by a more virulent strain. Sugarbeet and Tetragonia expansa were selected for these tests. Plants in an early stage of development were inoculated with a mild strain of the virus which caused yellowing of older leaves of the inoculated plants, but which produces no effects on the young leaves. After the plants had grown to considerable size and had presumably become completely invaded by the mild virus strain, the plants were reinoculated with a strain that produces marked vein clearing on young leaves. At the same time, plants of the same age, but which had not been inoculated with a mild virus strain, were inoculated with the more virulent strain.

Beet and T. expansa plants inoculated with the nonvirulent strain 1 in the seedling stage produced yellowing of older leaves in 20 to 30 days and continued to produce this type of symptom until discarded several months later.

Plants of the two test species inoculated in the seedling stage with strain 1 and reinoculated 60 days later with the virulent strain 5, started producing vein clearing in the young leaves 10 to 15 days after the second inoculation. Beet plants recovered to the point where they no longer produced vein clearing, but necrosis of old leaves was conspicuous. T. expansa plants also produced vein clearing in young leaves in 10 to 15 days, and they continued to produce vein clearing in young leaves until they were discarded.

Beet and T. expansa plants inoculated only with strain 5 at the time of reinoculation of the above groups of plants, produced the same type of symptoms as those produced by the combination.

Plants inoculated with strain 5 in the seedling^{stage} and reinoculated 60 days later with strain 1 showed no effects of strain 1.

Similar results were obtained in a repetition of this test in which the avirulent strain 3 and the virulent strain 5 were used.

It seems obvious from the results of this test that neither strain 1 nor strain 3 protect against infection or injury by the virulent strain 5. Whether there is any cross-protection in the reverse order was not determined because of the difficulty of detecting the weaker virus strain in the presence of the stronger.

It seems evident from these results that there was no cross-protection between virulent and avirulent isolates used in these tests. Whether this has any bearing on relationships of the different isolates, however, is questionable, since there is little or no cross-protection between isolates of other sugarbeet viruses such as curly top virus. In this case it would seem that the relationships of the avirulent strains to the vector and to differential host plants are more important in indicating relationships than the cross-protection test.

A Comparison of English Sugar Beet Mild Yellows with American Beet Western Yellows

In 1958 Russell (5) differentiated two presumably unrelated viruses that cause yellowing of sugarbeet in East Anglia, England, which he called sugar beet yellows virus (SBYV) and sugar beet mild yellows virus (SBMYV). In 1960 Duffus (3) separated a second virus from the yellows complex in California which is now called beet western yellows virus. There is general agreement that beet yellows virus (BYV) in America is essentially the same as sugar beet yellows virus (SBYV) is in England. There has been some question, however, as to whether beet western yellows virus (BWYV) is the same virus as sugar beet mild yellows virus (SBMYV). This is a question of more than academic importance, for, if the two complexes are separate and unrelated they pose serious additional threats to the sugarbeet industries of the two countries as well as to other parts of the world where both do not occur. Beet western yellows in the United States is capable of causing 10 to 20 percent reduction in yield and somewhat higher losses have been reported from sugar beet mild yellows in England. If SBMYV is wholly unrelated to any yellows virus that occurs in the United States, introduction of this virus could result in a relatively large increase in damage to the sugarbeet crop in certain areas of this Country. Conversely, introduction of beet western yellows virus into England and other parts of Europe could result in serious additional losses.

In view of the possible importance of BWYV and SBMYV if they are different and unrelated entities, an effort has been made to evaluate the evidence as to possible differences between the two complexes and to make some additional tests. Dr. Russell's laboratory at the Plant Breeding Institute near Cambridge, England, was visited in September 1964 and results of his tests on sugarbeet and a number of other hosts were observed. Symptoms on sugarbeet and Capsella bursa-pastoris produced in the greenhouses at Cambridge by SBMYV were identical, so far as determined, to those produced on these plants by BWYV in the United States. Also, Chenopodium capitatum appears to be immune to infection by mild isolates in both countries.

Dr. Russell reports that SBMY is much more prevalent than SBY in East Anglia, but that the more virulent strains of SBYV produce more damage to individual plants than SBMYV. Following the separation of the root and seed crop in England, incidence of SBY was greatly reduced but incidence of SBMY was not greatly affected. Thus, a break in the cycle of beet growing did not control the SBMY disease. Similar results have been obtained with BY and BWY with beet-free periods in California.

In summary it may be stated that SBMYV in East Anglia and BWYV in the United States have the following points in common:

1. Both diseases are milder than beet yellows on sugarbeet.
2. Both SBMYV and BWYV have longer incubation periods in beet plants than does beet yellows virus.
3. Neither virus produces symptoms on young leaves of sugarbeet.
4. Neither virus has been transmitted by the bean aphid, Aphis fabae.
5. Both viruses are persistent in the green peach aphid, Myzus persicae.
6. Chenopodium capitatum is solidly immune to both viruses.
7. Both viruses produce yellowing or reddening of Capsella bursa-pastoris.
8. Beet-free periods have less effect in restricting spread of these viruses than they do in the spread of beet yellows virus.

The only differences that have been suggested between the mild yellowing viruses in England and America are that SBMYV produces more damage on beet than BWYV and has a more restricted host range among representatives of the Cruciferae. Brassica pekinensis, for instance, is immune to SBMYV. However, this species is apparently immune to at least 4 isolates of BWYV tested at Salinas. There is some question also regarding the greater damage produced by SBMYV on beets in East Anglia. Comprehensive field tests have not been reported.

It is of interest in this connection that there has been evidence of two yellowing viruses of sugarbeet in Europe for as long as 16 years. Clinch and Laughnane (2) in 1948 described a mild and a severe yellows of beets in Ireland. These, in all probability, are the same diseases described by Russell later. Watson (7) in 1951, described mild and severe yellows in England that were undoubtedly Russell's sugar beet yellows and sugar beet mild yellows. In the United States beet western yellows was probably described by H. Mendelson of the Spreckels Sugar Company as early as 1900.

From the evidence which has accumulated thus far it seems reasonably certain that sugar beet mild yellows in East Anglia is the same disease as beet western yellows in the United States. Differences that may exist probably will be found to be differences between strains within the respective complexes. It would hardly be expected that the mild yellowing of beets that has apparently occurred in both England and the United States over a period of many years would be caused by unrelated viruses restricted to the respective areas. Serological and morphological studies of mild yellowing viruses in England and the United States should furnish additional evidence of the relatedness or unrelatedness of viruses causing mild yellowing of beets in the two areas, but even in the absence of such evidence, it seems unlikely that there is serious danger of increased damage from spread of this type of virus from one area to the other.

Literature Cited

1. Bennett, C. W. 1960. Sugar beet yellows disease in the United States. U.S.D.A. Tech. Bul. 1218, 63 pp.
2. Clinch, Phyllis E. M., and J. B. Laughnane. 1948. Seed transmission of virus yellows of sugar beet (Beta vulgaris L.) and the existence of strains of this virus in Eire. Sci. Proceed. Royal Dublin Soc. 24 (N.S.):307-318.
3. Duffus, James E. 1960. Radish yellows, a disease of radish sugar beet and other crops. Phytopathology 50:389-394.
4. Duffus, James E. 1961. Economic significance of beet western yellows (radish yellows) on sugar beet. Phytopathology 51:605-607.
5. Russell, G. E. 1958. Sugar-beet yellows: a preliminary study of the distribution and interrelationships of viruses and virus strains found in East Anglia, 1955-57. Ann. Appl. Biol. 46:393.
6. Russell, G. E. 1960. Sugar-beet yellows: further studies of viruses and virus strains and their distribution in East Anglia, 1958-59.
7. Watson, M. A. 1951. Beet yellows virus and other yellowing virus diseases of sugar beet. Rothamsted Exp. Sta. Rept. 1951:1-11. 1951.

ADDITIONAL STRAINS OF THE CURLY TOP VIRUS ^{1/}

Introduction

Giddings (3,4,5) has described 12 strains of curly top virus that differ in virulence on sugarbeet, tobacco and tomato. They differ also in some instances in type of symptoms produced and in host range. Highly virulent strains of the curly top virus have been described more recently (2); and at least 3 strains that appear to be mutants, and which produce vein yellowing on beet or tobacco (1), are known.

During the past year, two additional strains of curly top virus have been found that may have considerable scientific interest and one may have economic importance. One of these was sent to the U.S. Agricultural Research Station in cucumber from Fort Stockton, Texas, by Kenneth M. Lindsay, and the other was sent to the Station in Chenopodium murale from the Imperial Valley of California by Robert A. Flock. Each strain has shown some rather unusual characteristics.

Virus from Fort Stockton, Texas

Cucumber plants were received from Fort Stockton, Texas, on July 22, 1964, and another lot of plants was received later. It is reported that one field of cucumbers was seriously affected. The early-planted cucumbers were killed, "complete die-off," and later plantings were stunted. Affected plants had short internodes and an abundance of male flowers. Plants infected later showed yellow foliage and dwarfing but no shortening of internodes.

Leafhoppers (Circulifer tenellus) were transferred from the cucumber plants received to seedling sugarbeet plants, to determine whether curly top virus was present. Nine beet plants of 181 inoculated showed curly top. From such a low percentage of infection it was not certain that the disease in question was caused by curly top virus, so further studies of the virus recovered were made.

Sugarbeet plants infected from cucumber plants from Fort Stockton showed a high degree of stunting but less vein swelling and leaf rolling than was produced by most other known strains of curly top virus.

Transfers were made from infected sugarbeet plants to a number of species known to be susceptible to curly top. Severe symptoms were produced on Turkish tobacco, tomato, and Capsella bursa-pastoris. Chenopodium murale, C. capitatum, and C. amaranticolor appeared to be immune. These species appear also to be immune to most of the strains of curly top virus that are virulent on sugarbeet.

^{1/} By C. W. Bennett

Transfers were made also to cucumber plants. Five seedlings in each of a number of 8-inch pots were inoculated by means of viruliferous beet leafhoppers at the rate of about 5 leafhoppers per plant. The Fort Stockton virus was used along with several other strains of different degrees of virulence on sugarbeet. The results, Table 1, show that there is little correlation between damage to sugarbeet and damage to cucumber with the different isolates used.

Table 2. Susceptibility of cucumber to infection with selected strains or isolates of the curly top virus.

Strain or isolate of virus used	Virulence of virus on sugarbeet	Plants inoculated ^{1/} and infected	Severity of symptoms on cucumber ^{2/}
Fort Stockton	Medium	25/25	3 to 5
Strain 11	High	0/5	-
Los Banos	Very high	5/5	2 to 3
Turkish	Low	0/5	-
Illinois	Medium	5/5	3 to 4

^{1/} Denominator indicates number of plants inoculated; numerator the number of plants infected.

^{2/} Severity of symptoms is indicated by the numerals 1 to 5, inclusive, in ascending order of severity.

Cucumber plants inoculated with the Fort Stockton virus began to show definite evidence of disease about 10 days after inoculation. Cotyledons showed a type of yellow spotting not evident on the check plants on which nonviruliferous leafhoppers fed. Leaves were darker green than normal leaves and they tended to roll slightly. Internodes were shorter than normal and the plants were stunted. From the results thus far it would appear that the virus isolated from cucumber plants from Fort Stockton might be capable of producing considerable damage on cucumber under field conditions if infection occurred in the seedling stage.

Virus from Chenopodium murale from the Imperial Valley

This virus isolate was transferred readily from Chenopodium murale to sugarbeet by the beet leafhopper.

Symptoms on a susceptible variety of sugarbeet (SL 742) were of medium severity, and no symptoms were observed on the resistant variety US 75. Vein swelling was not severe on SL 742 and there was only a moderated degree of leaf rolling. Turkish tobacco, tomato, and Capsella bursa-pastoris were severely affected.

Some of the more severe effects were produced on Chenopodium murale and C. amaranticolor. Plants of C. murale showed vein clearing and leaves tended to turn downward. Very little growth was produced after first symptoms appeared, and some of the infected plants died. Symptoms were even more evident on C. amaranticolor. Striking vein clearing appeared in young leaves. The leaves became distorted and rolled into knot-like shapes. Plants were severely stunted and grew very little after symptoms appeared.

Discussion

Although neither of these virus isolates would seem to pose any additional threat to the sugarbeet industry, the fact that such previously unknown strains of the virus occur has significance in the overall curly top picture. These strains of virus either have been produced by mutation, more or less recently, or they have existed as undetected entities.

Recent recoveries of strains of virus more highly virulent in sugarbeet than any strain known previously have indicated that the curly top virus is not necessarily a stable entity and that strains more virulent on sugarbeet may be developed under natural conditions (2). The finding of a strain that causes marked vein yellowing on tobacco and 2 strains that cause marked vein yellowing on sugarbeet, emphasize the probable instability of the curly top virus. The discovery of two additional strains of virus, one of which may be highly damaging to cucumber, and one capable of causing severe damage to Chenopodium murale, a species on which symptoms had not previously been known to be produced by any North American strain of the virus, lends still further support to the theory that new strains of the virus are being produced under natural conditions.

Literature References

1. Bennett, C. W. 1957. Interaction of sugar-beet curly top virus and an unusual mutant. *Virology* 3:322-342.
2. Bennett, C. W. 1963. Highly virulent strains of curly top virus in sugar beet in western United States. *Jour. Amer. Soc. Sugar Beet Tech.* 12:515-520.
3. Giddings, N. J. 1938. Studies of selected strains of curly top virus. *Jour. Agr. Res.* 56:883-894.
4. Giddings, N. J. 1944. Additional strains of the sugar-beet curly top virus. *Jour. Agr. Res.* 69:149-157.
5. Giddings, N. J. 1954. Two recently isolated strains of curly top virus. *Phytopathology* 44:123-125.

BEET PSEUDO-YELLOWS VIRUS,
TRANSMITTED BY THE GREENHOUSE
WHITEFLY (TRIALEURODES VAPORARIORUM)

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SUMMARY

A previously undescribed yellowing disease of sugarbeet, spinach, cucumber, flax, lettuce, carrot, and other crop, ornamental, and weed hosts has been found in the Salinas Valley of California. The inciting agent, herein called beet pseudo-yellows virus, is transmitted by the common greenhouse whitefly, Trialeurodes vaporariorum. Single viruliferous whiteflies were capable of transmitting the virus. The virus was acquired by nonviruliferous insects in a feeding period of 1 hr and was transmitted to healthy plants by viruliferous individuals within a 1-hr feeding period. The latent period in the vector, if any, is less than 6 hrs. The virus was retained by whiteflies for 6 days in serial transfers on a susceptible host but definitely lost transmitting ability after this period. The relationships of the beet pseudo-yellows virus to its vector are in general similar to those of previously described whitefly-transmitted viruses, but the virus is distinct from other whitefly-transmitted viruses in symptom expression and in host range.

INTRODUCTION.--Greenhouse studies of the yellows complex of sugarbeet involves constant concern over the possibility of greenhouse contamination. Nonviruliferous aphid colonies are checked on healthy indicator plants each time aphids are used in transmission studies and noninfected plants are used also as a check against greenhouse spread of the yellows viruses. Yellowing contaminations became numerous and seriously threatened the beet indexing and strain differentiation work despite the lack of viruliferous aphids in insectary compartments or in the greenhouse, but following a slow buildup of the common greenhouse whitefly, Trialeurodes vaporariorum (Westwood). Laboratory transmission tests have shown that this insect transmits the previously undescribed yellowing virus to sugarbeet and other crop and weed plants. The disease on these hosts, although unrelated, closely resembles in symptom expression the other beet yellows disease and is designated herein as beet pseudo-yellows.

MATERIALS AND METHODS.--The greenhouse whitefly, T. vaporariorum, used in these tests was collected in the greenhouse and identified by Louise M. Russell, Entomology Research Division, U.S.D.A. Colonies were reared in rectangular cloth and glass-sided cages. Viruliferous colonies were reared on virus infected Malva parviflora L. plants. Nonviruliferous whiteflies were reared on Solanum dulcamara L. Insects were moved with an aspirator tube connected to a water suction apparatus. Cloth-covered cylindrical cages were used to enclose plants that were to be infested with large numbers of insects. In tests ⁱⁿ which smaller numbers of insects were confined to plants or in tests in which the insects were moved from plant to plant, small clip-type leaf cages as described by McLean (1) were used.

After routine tests with whiteflies, all plants were sprayed with malathion. After treatment, plants were placed in greenhouses which were fumigated at weekly intervals with nicotine and tetraethyl pyrophosphate (TEPP). The gradual buildup of whiteflies in the greenhouses which preceded the discovery of beet pseudo-yellows followed a program of fumigation with only nicotine. Since the discovery of the relationship of the greenhouse whitefly to the virus the addition of TEPP to the weekly fumigation and occasional spraying with malathion has practically eliminated the insect from the greenhouse. Noninfested plants were placed in the greenhouse with each series of plants inoculated as a check for contamination by viruliferous whiteflies. Since the start of the intensified whitefly control program no obvious contaminations have been evident.

RESULTS.--Economic importance.--Thus far, the beet pseudo-yellows virus has been isolated from the Salinas greenhouse and from 2 weed species (Conium maculatum L. and Taraxacum officinale from various locations in the Salinas Valley. However, few attempts have been made to determine the incidence and distribution of the virus under field conditions. The virus is potentially important. The vector T. vaporariorum is an abundant and destructive species in greenhouses, and outside in warmer climates. It has numerous host plants and world-wide distribution (2).

In the greenhouse, the virus caused yellowing type diseases of sugarbeet (Beta vulgaris L.), spinach (Spinacia oleracea L.), cucumber (Cucumis sativus L.), squash (Cucurbita moschata Dcne.), muskmelon (Cucumis melo L.), flax (Linum usitatissimum L.), lettuce (Lactuca sativa L.), carrot (Daucus carota L.), and several ornamentals and may occur in these species in nature.

The disease is probably not economically significant on sugarbeet under field conditions, since the insect is not commonly found on this plant. The disease can be confusing, however, in a greenhouse research program on strains and vectors of the sugarbeet yellows viruses, because of the close similarity of symptoms induced on common host plants.

Host range.--The host range was determined by infesting at least 6 seedlings of each species tested with 30-50 viruliferous whiteflies for 48 hrs. Presence or absence of virus in each plant species tested for susceptibility was determined by whitefly transfer to shepherd's-purse seedlings about 60 days after inoculation.

Plants susceptible to beet pseudo-yellows virus are listed in alphabetical order:

- AMARANTHACEAE.--Gomphrena globosa L.
CARYOPHYLLACEAE.--Spergula arvensis L.
CHENOPODIACEAE.--Beta macrocarpa Guss., B. vulgaris L., Chenopodium album L., C. amaranticolor Coste & Reyn., C. capitatum (L.) Asch., C. murale L., Spinacia oleracea L.
COMPOSITAE.--Callistephus chinensis (L.) Nees, Cichorium endiva L., Lactuca sativa L., L. serriola L., Senecio vulgaris L., Sonchus oleraceus L., Taraxacum officinale Webber, Zinnia elegans Jacq.
CRUCIFERAE.--Capsella bursa-pastoris (L.) Medic.
CUCURBITACEAE.--Cucumis sativus L., C. melo L., Cucurbita moschata Dcne.
GERANIACEAE.--Erodium cicutarium (L.) L'Her., Geranium dissectum L.
LINACEAE.--Linum grandiflorum Desf., L. usitatissimum L.
MALVACEAE.--Malva parviflora L.
PORTULACAEAE.--Claytonia perfoliata Donn.
RANUNCULACEAE.--Aquilegia sp.
SOLANACEAE.--Nicotiana clevelandii Gray, N. glutinosa L., N. tabacum L., Physalis ixocarpa Brot., P. wrightii Gray, Solanum dulcamara L.
UMBELLIFERAE.--Conium maculatum L., Daucus carota L.
URTICACEAE.--Urtica californica Green.
Plants showing no indication of infection include:
AIZOACEAE.--Tetragonia expansa Murr.
COMPOSITAE.--Helianthus annuus L.
CONVOLVULACEAE.--Ipomoea nil (L.) Roth, I. purpurea (L.) Lam., I. tricolor Cav.
CRUCIFERAE.--Raphanus sativus L., Sisymbrium irio (L.) Britt., Thlaspi arvense L.
CUCURBITACEAE.--Citrullus vulgaris Schrad, Cucurbita pepo L.
LEGUMINOSAE.--Medicago sativa L., Phaseolus vulgaris L.
MALVACEAE.--Althaea rosea (L.) Cav., Gossypium hirsutum L., Hibiscus esculentus L., Lavatera assurgentiflora Kellogg, Malva sylvestris L.
SOLANACEAE.--Datura stramonium L., Lycopersicon esculentum Mill., Nicandra physaloides (L.) Gaertn., Physalis floridana Rybd.

Symptoms.--Species infected by the beet pseudo-yellows virus showed, in general, stunting, interveinal yellowing and/or chlorotic spotting. Species that naturally have red pigment tended to show intensification of red color in interveinal areas when infected. Symptoms on many of the common host plants were very similar to symptoms induced by beet yellows, beet western yellows, and malva yellows viruses, all of which are aphid transmitted. Symptoms on a selected group of host plants follow.

Beta vulgaris.--Infected sugarbeet plants showed chlorotic spotting or splotching uniformly on the older and intermediate leaves. As the disease progressed, the yellowing became more intense and more general. Older infected leaves were chlorotic, except for scattered small islands of green tissue. In the older leaves, there were also irregular 1-1½ cm diam bright yellow colored areas. Leaves were thickened and brittle. The yellowing symptoms were more uniform, with less tendency toward sectoring and green veins than with beet and western yellows.

Capsella bursa-pastoris.--Greenhouse inoculated shepherd's purse plants showed initial symptoms 15-20 days after inoculation. Lower leaves developed severe chlorosis and moderate leaf curl. As the disease progressed, the yellowing developed acropetally. Yellow leaves were thickened and brittle. The symptoms were similar to symptoms induced by the beet western yellows virus on this host.

Lactuca sativa.--Infected lettuce plants exhibited severe interveinal yellowing symptoms on the older and intermediate leaves. Symptoms were similar to those induced by the beet western and malva yellows viruses.

Linum usitatissimum.--Greenhouse infected flax showed marked interveinal yellowing, especially near the leaf margins and base of the leaves on the lower 2/3 of the plant. Beet pseudo-yellows symptoms on this host were indistinguishable from symptoms induced by beet western and malva yellows viruses.

Chenopodium capitatum.--Infected plants showed symptoms similar to those induced by mild isolates of the beet yellows virus. Striking interveinal reddening of the older leaves was characteristic. Beet pseudo-yellows virus infected plants, however, showed slightly more purple coloration and a sharper contrast between the interveinal areas and the green veins than beet yellows virus infected plants.

Taraxacum officinale.--Older leaves of infected plants showed reddening and chlorosis of interveinal areas which, at times, was sharply delimited by the veins.

Nicotiana glutinosa.--Bright, interveinal yellowing symptoms with dark-green veins were characteristic of beet pseudo-yellows virus in this host.

Cucumis melo.--Small (1-mm diam), orange-yellow colored, raised areas occurred on the intermediate and older leaves of affected muskmelon. Later these areas coalesced to form large thickened areas on the leaf surface. Irregular necrotic areas then developed and the leaves died prematurely. Plants were rather severely stunted.

Transmission tests.--1) Mechanical.--Numerous attempts were made to transmit the beet pseudo-yellows virus mechanically by routine techniques that included the use of abrasives, phosphate buffer, and sodium sulphite. Virus sources used included sugarbeet, shepherd's-purse, and N. clevelandii. The plants inoculated included these and a number of other species found to be susceptible when inoculated by the whitefly vector. The results were negative in all tests.

2) Insects.--Preliminary studies had indicated that the beet pseudo-yellows virus was readily transmitted by the greenhouse whitefly (T. vaporariorum). However, because of the similarity in symptoms to the aphid-transmitted yellows viruses of beet, it was desirable to determine whether common aphid vectors of these viruses could transmit the whitefly-transmitted virus. Tests to determine whether some of the common aphid species are vectors of beet pseudo-yellows virus were carried out with beet, shepherd's-purse, or sowthistle as the virus source and test plants. Nonviruliferous aphids of the various species tested were placed on the source plants for 24 hrs and then about 25 individuals were transferred to each of a number of test plants for an infection feeding period of 48 hrs. Under these conditions none of the aphid species used was capable of transmitting the beet pseudo-yellows virus. These species included Amphorophora lactucae L., Aphis fabae Scop., Macrosiphum-barri Essig, and Myzus persicae (Sulz.).

Virus-vector relationships.--1) Relation of numbers of insects to virus transmission.--Viruliferous whiteflies reared on diseased M. parviflora plants were used in tests to determine the relative efficiency of different numbers of insects in securing infection with the beet pseudo-yellows virus. The whiteflies, singly or in groups of 5, 10, 20 or 40, were allowed a 48-hr infection feeding period on shepherd's-purse test plants. The results (Table 1) indicate that single greenhouse whiteflies are capable of transmitting the beet pseudo-yellows virus. Transmission increased markedly, however, when larger numbers of insects were used. In tests to determine other properties of the virus groups of 20 insects were used.

2) Acquisition feeding period.--The feeding time on a virus source plant required for nonviruliferous greenhouse whiteflies to become infective was studied over a feeding period range of 1 to 48 hrs. After the feeding period on diseased shepherd's-purse, the insects were removed in groups of 20 and placed on shepherd's-purse seedlings for a 48-hr infection feeding. The results (Table 2) indicate that the insects may become viruliferous in a 1-hr feeding period. The transmission efficiency of the vectors increased with an increase in feeding time on the virus source.

3) Infection feeding period.--Tests designed to determine the time required for viruliferous whiteflies to transmit the beet pseudo-yellows virus were conducted, using feeding periods of 1 to 48 hrs with insects reared on diseased cheeseweed. Groups of 20 insects were placed on each of the shepherd's-purse test plants and were permitted to feed for designated periods. The results (Table 3) indicate that viruliferous whiteflies were capable of inducing infection within a

Table 1.--Relation of numbers of greenhouse whiteflies to transmission of beet pseudo-yellows virus

Test no.	No. of shepherd's-purse seedlings infected out of 8 inoculated when colonized with the indicated no. of viruliferous insects per plant				
	1	5	10	20	40
1	2	7	5	6	8
2	0	1	2	3	5
3	0	4	4	5	5
4	1	7	7	8	8
5	0	2	2	5	6
6	2	7	8	8	8
% transmission	10.4	58.3	58.3	72.9	83.3

Table 2.--Results of tests to determine the time required for nonviruliferous greenhouse whiteflies to become infective with the beet pseudo-yellows virus

Test no.	No. of shepherd's-purse seedlings infected out of 8 inoculated with groups of 20 insects fed on the virus source for the indicated period in hrs					
	1	3	6	12	24	48
1	0	2	2	3	6	6
2	1	4	5	5	8	7
3	1	2	1	1	4	2
4	0	2	1	4	6	8
5	0	1	2	2	5	4
6	0	0	2	4	6	7
% transmission	4.2	22.9	27.1	39.6	72.9	70.8

Table 3.--Results of tests to determine the feeding time required by 20 viruliferous greenhouse whiteflies to infect shepherd's-purse seedlings with the beet pseudo-yellows virus

Test no.	No. of plants infected out of 8 on which the whiteflies were allowed to feed for the indicated period in hrs.					
	1	3	6	12	24	48
1	1	3	8	8	8	8
2	0	2	3	3	4	7
3	0	4	7	7	5	8
4	2	3	7	8	8	8
5	0	4	3	5	6	8
6	1	2	6	6	7	7
% transmission	8.3	37.5	70.8	77.1	79.2	95.8

1-hr feeding interval. Viruliferous insects induced infection after a 6-hr feeding period at a high level of efficiency.

4) Latent period of the virus in the vector.--The latent period of the beet pseudo-yellows virus in the vector was studied by allowing nonviruliferous whiteflies to feed on a virus source for 3, 6, or 12 hrs and then transferring them in groups of 20 per plant to healthy shepherd's-purse for the necessary time intervals to permit testing for latent periods of 6, 12, 24, and 48 hrs. The results (Table 4) indicate that the latent period in the vector, if any, is less than 6 hrs.

5) Persistence.--The ability of viruliferous greenhouse whiteflies to retain the beet pseudo-yellows virus was determined by 2 methods. Whiteflies reared on diseased cheeseweed plants were transferred in groups of 20 in daily serial transfers on healthy shepherd's-purse seedlings. The results (Table 5) show that all groups of insects lost transmitting ability in 6 days or less. Although insects in the different groups died at various times, at the termination of the experiment (15 days), there was still an average of approximately 4 individuals per group.

The ability of viruliferous whiteflies to retain the beet pseudo-yellows virus when feeding on an immune host was determined by placing insects reared on diseased cheeseweed on immune cotton (Gossypium hirsutum) or tomato (Lycopersicon esculentum) plants and then testing the whiteflies at intervals by transferring them to shepherd's-purse seedlings. Under these conditions, the virus was retained by the vector for a maximum of 4 days.

DISCUSSION.--Symptoms induced by beet pseudo-yellows virus on common host plants are quite distinct from those induced by the some 23 previously described whitefly-transmitted viruses. Beet pseudo-yellows virus induces, in general, interveinal yellowing or reddening symptoms on leaves of affected plants (similar to symptoms induced by several persistent aphid-transmitted viruses). One group of whitefly-transmitted viruses induces color deviations of the variegation type on affected leaves. The other major group of whitefly-transmitted viruses produces malformations (leaf curl, vein thickening, or enations) on affected plants. Beet pseudo-yellows virus is readily distinguished from these viruses on the basis of symptom expression, host range and vector species.

An extensive review of the transmission of plant viruses by whiteflies has recently been published by Varma (3). Beet pseudo-yellows virus is similar to many of the other whitefly-transmitted viruses in virus-vector relationships. Thus far, all described whitefly viruses have been of the persistent or semi-persistent types.

Table 4.--Results of tests to determine the latent period of the beet pseudo-yellows virus in the greenhouse whitefly

Test no.	Feeding period on virus source in hrs	No. of shepherd's-purse seedlings infected out of 8 inoculated with 20 insects in which the virus had the indicated latent period in hrs			
		6	12	24	48
1	3	1	3	2	2
	6		4	5	2
	12			4	6
2	3	0	0	0	0
	6		1	3	1
	12			7	6
3	3	1	4	0	7
	6		6	8	5
	12			7	8

Table 5.--Shepherd's-purse seedlings infected (+) and uninfected (-) in daily serial transfers using groups of 20 viruliferous greenhouse whiteflies reared on a beet pseudo-yellows source plant

Whitefly colony no.	Successive daily transfers														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
2	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
3	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
4	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
5	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
6	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
7	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
8	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
9	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
10	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
11	+	+	+	+	+	-	+	-	-	-	-	-	-	-	-
12	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
13	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-
14	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
15	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
16	+	+	+	+	+	-	+	-	-	-	-	-	-	-	-

LITERATURE CITED

1. McLean, Donald L. 1962. Transmission of lettuce mosaic by a new vector, Pemphigus bursarius. Jour. Econ. Ent. 55: 580-583.
2. Russell, Louise M. 1963. Hosts and distribution of five species of Trialeurodes (Homoptera: Aleyrodidae). Ann. Ent. Soc. Amer. 56: 149-153.
3. Varma, P. M. 1963. Transmission of plant viruses by whiteflies. Bull. Nat. Inst. Sci. India 24: 11-33.

BEEET YELLOW STUNT VIRUS

James E. Duffus

A potentially destructive yellows type virus disease of sugarbeet and lettuce was recognized in 1963 as being distinct from other yellows type viruses affecting these crops. The disease is widespread and of high incidence on sowthistle (Sonchus oleraceus L.) in the Salinas Valley, California, at all times of the year. The incidence of the disease in sugarbeet and lettuce crops is not known.

The beet yellow stunt virus appears to be quite distinct from beet yellows, western yellows and malva yellows viruses on the basis of host and vector relationships. The virus is semi-persistent in its aphid vector and is readily distinguished from malva and western yellows viruses on this basis. Retention of the virus by the vector is of similar duration to the retention of beet yellows virus in its vector, but host reactions are quite different.

Greenhouse infected sugarbeet plants show a marked shortening of petioles of the newly affected leaves. Vein clearing appears on the young leaves, followed by irregular yellow blotching and leaf distortion. Greenhouse inoculated lettuce is markedly stunted and show severe interveinal yellowing. Veinal necrosis is sometimes present causing twisting, distortion, and sometimes death of infected plants.

In addition to the hosts already mentioned, the virus has been transmitted to and recovered from Beta macrocarpa Guss., Chenopodium capitatum (L.) Asch., Claytonia perfoliata Donn, Geranium dissectum L., Lactuca serriola L., Nicotiana clevelandii Gray, and Zinnia elegans Jacq. The virus is apparently not mechanically transmitted but is transmitted by at least 3 aphid species, Myzus persicae Sulz., Amphorophora lactucae (L.), and Macrosiphum euphorbiae (Thomas).

P A R T IX

RHIZOCTONIA INVESTIGATIONS

Selecting for Resistance and Utilization
of Inoculation Techniques

Foundation Project 25

J. O. Gaskill

Research conducted in cooperation with the Botany and Plant
Pathology Section, Colorado Agricultural Experiment Station.

RHIZOCTONIA INVESTIGATIONS, FORT COLLINS, COLORADO, 1964 ^{1/}

(A phase of Beet Sugar Development Foundation Project 25)

John O. Gaskill

Research on methods of evaluating Rhizoctonia resistance of sugarbeet strains or lines under field conditions continued to receive major emphasis at Fort Collins in 1964. Selection and breeding for Rhizoctonia resistance and preliminary evaluation of resistance of breeding strains also were continued. A set of 26 strains, furnished by the Great Western Sugar Company, were included in the evaluation program. This report is confined largely to the principal 1964 methods study, Experiment R-1. The term, Rhizoctonia, as used in this report with reference to the diseased sugarbeet, pertains to the root-rot or crown-rot types of attack and has nothing to do with Rhizoctonia foliage blight.

Material and Methods

The set of sugarbeet varieties or strains used in Experiment R-1, 1964, included the same set used in a methods study in 1963 (1)^{2/} with one additional variety. The 1964 set may be described as follows:

<u>Strain</u> <u>no.</u>	<u>Ft. Collins</u> <u>seed no.</u>	<u>Description</u>
1	Acc. 2233	SP 5831-0; a monogerm, U.S.D.A. variety, resistant to leaf spot and black root.
2	SP 621004-0	A product of selecting for Rhizoctonia resistance, at Ft. Collins, in SP 5831-0.
3	Acc. 2168	GW 674-56C; a multigerm, G.W.S. Co., leaf spot resistant variety.
4	SP 631001-0	Increase of SP 611107-0; a product of selecting for Rhizoctonia resistance, at Ft. Collins, in GW 674-56C.
5	Acc. 2518	C 817 (G.W.S. Co.); an increase of LeRoy Powers' Select A54-1 Synthetic; multigerm; leaf spot resistant; derived from GW 359.

^{1/} A progress report on investigations conducted by the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Colorado Agricultural Experiment Station and the Beet Sugar Development Foundation.

^{2/} Numbers in parentheses refer to Literature Cited.

- | | | |
|---|-------------|--|
| 6 | SP 621003-0 | A product of selecting for Rhizoctonia resistance, at Ft. Collins, in C 817. |
| 7 | Acc. 2057 | US 401; a multigerm, U.S.D.A. variety, resistant to leaf spot and black root. |
| 8 | Acc. 2591 | SP 5822-0; a multigerm, U.S.D.A. variety, resistant to leaf spot and black root. |

Dry, ground, barley-grain inoculum was prepared as previously described (2). The rosette method (2), with one-sixth teaspoon of inoculum per plant, placed in the center of the foliar rosette approximately 3 weeks after thinning, served as a standard inoculation technique. A side-dressing technique involved placement of inoculum in a narrow band, about 3 inches from the beet row and 1 inch below the soil surface, at a rate of 1 tablespoon per 14 ft. of row. As originally planned, all inoculations were to be performed on a single date, and planting was to be so timed as to provide a suitable array of plant ages at the time of inoculation. Unfavorable weather forced a planting delay in those plots scheduled for earliest planting, and the following modified set of inoculation "treatments" was adopted:

Treat. symbol	Inoculation method	Dates of			No. of days, plant. to inoc.
		Planting	Thinning	Inoc.	
a	Side-dress	6/29	7/27	7/7	8
b	" "	6/16	7/13	7/7	21
c	" "	6/3	6/29	7/7	34
d	Rosette	6/3	6/29	7/22	49

Where inoculation preceded thinning, special care was used to avoid disturbing the inoculum during the thinning process. In soil type and fertility, experimental design, irrigation practices, and general care of the crop, the 1964 experiment was similar to Experiment R-1 of 1963 (1). The same highly pathogenic isolate of Rhizoctonia (B-6) was used in both years.

Results and Discussion

Results of Experiment R-1, 1964, are presented in Table 1 as percentages of surviving plants in inoculated subplots on 3 dates. Rhizoctonia attack was very severe, and only 5.4 percent of the entire inoculated population remained alive at harvest. However, several noteworthy trends may be observed in the summarized results.

Where the rosette inoculation method (d) was used, average survival percentages were substantially lower in the low-moisture area than in

Table 1.--Comparative survival percentages of sugarbeet strains as influenced by Rhizoctonia inoculation technique and soil moisture, 1964. Basic results presented as 2-plot averages.

Date		Strain:				High moisture a/				Low moisture				: Aver., high and low moisture			
		no.:	a	b	c	d	aver.:	a	b	c	d	aver.:	a	b	c	d	aver.:
8/5		1	38.6	28.2	41.5	69.9	44.5	79.1	59.1	63.3	47.2	62.2	58.8	43.7	52.4	58.5	53.3
		2	57.5	39.6	30.0	74.6	50.4	58.0	54.0	69.5	60.7	60.5	57.8	46.8	49.7	67.7	55.5
		3	35.1	40.4	76.4	49.9	50.4	84.8	62.7	45.2	29.3	55.5	59.9	51.6	60.8	39.6	53.0
		4	50.6	21.1	55.0	66.2	48.2	74.5	61.6	55.2	56.2	61.9	62.6	41.3	55.1	61.2	55.0
		5	35.9	40.8	57.2	66.3	50.0	54.4	66.1	51.5	53.8	56.4	45.1	53.4	54.4	60.0	53.2
		6	49.1	50.0	73.4	82.3	63.7	67.7	66.8	70.5	69.8	68.7	58.4	58.4	72.0	76.0	66.2
		7	35.9	39.6	44.1	38.7	39.5	70.4	63.5	31.5	42.9	52.1	53.1	51.5	37.8	40.8	45.8
		8	34.3	34.6	50.0	56.3	43.8	70.1	57.7	44.7	38.3	52.7	52.2	46.2	47.3	47.3	48.2
Average			42.1	36.8	53.4	63.0	48.8	69.9	61.4	53.9	49.8	58.7	56.0	49.1	53.7	56.4	53.8
8/17		1	11.6	7.7	4.1	12.6	9.0	55.0	29.6	29.2	11.5	31.3	33.3	18.6	16.6	12.0	20.1
		2	29.7	22.7	7.2	26.8	21.6	39.6	25.0	21.4	9.4	23.8	34.7	23.8	14.3	18.1	22.7
		3	8.4	11.1	33.4	9.5	15.6	57.0	43.3	16.3	5.5	30.5	32.7	27.2	24.8	7.5	23.0
		4	25.1	1.1	15.3	20.3	15.4	45.7	37.5	24.7	10.0	29.5	35.4	19.3	20.0	15.1	22.4
		5	9.2	7.5	13.2	18.8	12.2	37.9	36.0	23.0	16.7	28.4	23.5	21.7	18.1	17.7	20.3
		6	25.8	18.3	34.0	43.1	30.3	42.9	40.1	39.4	26.1	37.1	34.3	29.2	36.7	34.6	33.7
		7	10.3	10.9	8.1	7.2	9.1	48.3	24.3	6.1	7.0	21.4	29.3	17.6	7.1	7.1	15.3
		8	6.4	2.6	20.4	11.0	10.1	39.4	21.8	13.5	3.0	19.4	22.9	12.2	16.9	7.0	14.7
Average			15.8	10.2	16.9	18.6	15.4	45.7	32.2	21.7	11.1	27.7	30.7	21.2	19.3	14.9	21.5
LSD (.05)													N.S.	N.S.	13.6	9.9	
F (strains)													0.60	1.73	3.48*	7.50**	
10/9		1	3.5	5.2	1.3	2.7	3.1	17.5	1.2	5.1	0.0	5.9	10.5	3.2	3.2	1.3	4.5
		2	5.6	3.5	2.9	8.5	5.1	20.4	2.6	4.0	2.7	7.4	13.0	3.0	3.5	5.6	6.3
		3	0.0	1.3	7.0	2.8	2.8	27.3	14.1	4.6	1.4	11.8	13.7	7.7	5.8	2.1	7.3
		4	5.5	0.0	0.0	6.7	3.1	21.1	3.0	3.0	4.3	7.8	13.3	1.5	1.5	5.5	5.4
		5	2.7	0.0	0.0	1.3	1.0	10.5	8.4	5.1	1.5	6.4	6.6	4.2	2.6	1.4	3.7
		6	9.2	9.8	10.5	19.9	12.3	16.1	7.2	10.7	5.6	9.9	12.6	8.5	10.6	12.7	11.1
		7	2.4	2.6	0.0	5.9	2.7	13.7	3.7	0.0	0.0	4.3	8.0	3.1	0.0	2.9	3.5
		8	0.0	0.0	0.0	4.7	1.2	7.5	0.0	1.5	0.0	2.2	3.8	0.0	0.7	2.4	1.7
Average			3.6	2.8	2.7	6.5	3.9	16.7	5.0	4.2	1.9	7.0	10.2	3.9	3.5	4.2	5.4

a/ The high moisture condition was begun on 7/15/64.

the high-moisture area at all 3 dates. Since moisture levels were not replicated, this observation would mean little of itself. However, since this trend is in agreement with the 1963 results (1) for the comparable inoculation technique--treatment 4--a causal relationship seems likely. On the other hand, where the side-dressing inoculation method was used, survival percentages were lower under the high-moisture conditions, especially for treatments a and b where the plants were quite young at the time of inoculation.

In general, differences among sugarbeet strains, in survival percentage, were relatively small where inoculation was performed by means of the side-dressing method, especially treatments a and b. In contrast, where the rosette method (d) was used, differences among strains were quite substantial. According to the F test, such differences, occurring on August 17, were highly significant. The relative standing of the respective strains (with treatment d) at that time and at harvest (Oct. 9) were similar, but the F test was not applied to the harvest results because of the frequent occurrence of zero values for individual sub-plots at that time.

Of special significance is the agreement between the 1964 and 1963 results where inoculation treatment d and its equivalent were used. The 2 years' data, summarized in Table 2, show striking strain contrasts both at mid-season and at harvest. Probably the high lights of the 2 years' results are the comparisons between strains 2, 4, and 6 (products of Rhizoctonia-resistance selection) and their respective parental varieties, 1, 3, and 5, as shown in Table 2 for the period, 4 to 7 weeks after inoculation. The average percentage survival for each of the strains, 2, 4, and 6, exceeded that of its parental variety by a highly significant amount. The over-all average percentage survival for strains 2, 4, and 6 was 220.0 percent of the average percentage survival for the parents at that time, and the corresponding "percent-of-parents" average at harvest was 274.7.

Conclusions

The following conclusions are based on cumulative evidence obtained from Rhizoctonia experimental work conducted at Fort Collins from 1956 through 1964.

1. The existence of differences among sugarbeet strains in resistance to Rhizoctonia has been clearly established.
2. Selection for Rhizoctonia resistance at Fort Collins has resulted in measurable improvement in that regard. However, none of the improved lines or other material evaluated at this station carries sufficient resistance to produce a satisfactory crop under severe Rhizoctonia exposure.

3. Of the various *Rhizoctonia* inoculation techniques studied, the rosette method appears to be the most dependable as a means of evaluating the resistance of sugarbeet strains. Differences among strains apparently can be detected best, using this method; if inoculation is postponed until the plants have attained considerable size. Inoculation 3 weeks after thinning has given better results than earlier inoculation. Whether further postponement would be desirable has not been determined.
4. It has been tentatively concluded that, in using the rosette inoculation method for *Rhizoctonia* resistance evaluation purposes, a moderately high soil moisture condition is preferable to low soil moisture because of a tendency toward lower severity of attack with higher moisture. Confirmation with refinement of moisture-control techniques is needed.

Literature Cited

- (1) Gaskill, John O. *Rhizoctonia* investigations, Fort Collins, Colorado, 1963. Sugarbeet Research, 1963 Report (CR-4-64, Crops Research Division, A.R.S., U.S.D.A.): 350-357.
- (2) Pierson, Victor G., and John O. Gaskill. 1961. Artificial exposure of sugar beets to *Rhizoctonia solani*. J. Am. Soc. Sugar Beet Technol. 11(7): 574-590.

Table 2.--Comparative survival percentages of sugarbeet strains, inoculated with Rhizoctonia by means of the rosette method three weeks after thinning, 1963 and 1964. Basic results presented as 4-plot averages.

Strain no.	4-7 weeks after inoc.				At harv. (11 weeks after inoc.)			
	1963	1964	Aver.	Aver. <u>a</u> / :(actual):(% of :parent):	1963	1964	Aver.	Aver. <u>a</u> / :(actual):(% of :parent):
1	8.7	12.0	10.35		4.4	1.3	2.84	
2	24.1	18.1	21.09	203.8	12.7	5.6	9.14	321.8
3	4.5	7.5	5.96		3.2	2.1	2.64	
4	16.3	15.1	15.68	263.1	8.5	5.5	6.99	264.8
5	14.0	17.7	15.85		9.3	1.4	5.34	
6	26.7	34.6	30.61	193.1	12.7	12.7	12.69	237.6
7	5.3	7.1	6.16		2.6	2.9	2.75	
8		7.0				2.4		
Average] (omit. #8)	14.2	16.0	15.10	220.0	7.6	4.5	6.05	274.7
LSD (.01)	11.8	13.5	8.51					
F	9.11**	7.50**						

a/ Strains 2, 4, and 6 are products of Rhizoctonia-resistance selection in the parental strains 1, 3, and 5, respectively.

P A R T X

CERCOSPORA LEAF SPOT INVESTIGATIONS

Lucas Calpouzos

G. F. Stallknecht

Research conducted in cooperation with Minnesota Agricultural
Experiment Station.

CERCOSPORA LEAF SPOT INVESTIGATIONS

L. Calpouzios and G. F. Stallknecht

Cercospora leaf spot remained the major sugar beet disease problem in the North Central United States in 1964. This year's research program studied the disease in the field, greenhouse, in environment chambers and laboratory.

Field Studies

Ground Spray Versus Aerial Spray for Leaf Spot Control

Sugar beet growers frequently ask whether aerial spraying at 5 gallons/acre can control leaf spot as well as ground spraying at 40-80 gallons/acre. When sprayed at high volumes by ground equipment, sugar beet leaves are thoroughly wetted on their upper surfaces on which the spray deposit appears uniform. When sprayed at low volumes by helicopter or airplane, sugar beet leaves show small, scattered droplets of the spray material. Both spray methods deposit the majority of the spray on the upper leaf surface. The coverage on aerial sprayed leaves does not appear as thorough as on ground sprayed leaves. Nevertheless, the effectiveness of a spray method should not be judged by its visual deposit alone; measurements of disease incidence and yield are needed. An experiment was carried out to compare the effectiveness of ground spray equipment with helicopter in controlling leaf spot.

Materials and Methods. The ground equipment, a modified Kromer sprayer, had a 33-foot boom with nozzles spaced 20 inches apart. Nozzle pressure was 300 lbs psi. The aerial equipment, a Bell Helicopter model 47G-2, carried a 32-foot boom with nozzles spaced 1 foot apart. Nozzle size was no. 6 and nozzle pressure was 25 lbs psi. The fungicide Dithane M-45 was sprayed in all treatments at 2 lbs per acre. A wetting agent, Triton B-1956, was included in the spray at 5-6 oz per acre. The helicopter travelled 45 mph as it applied the fungicide at 5 gallons per acre. The ground equipment travelled at 2.5 mph and applied 40 gallons per acre.

Four applications of the fungicide were spaced at about 2-week intervals. The first spray was applied when the first few Cercospora leaf spots were observed on about half of the plants in the experimental area. The following were the helicopter spray dates: July 20, August 3, August 16, and September 6. The ground equipment sprayed within 3 days of the above dates. Harvest occurred on October 7, 31 days after the final spray.

The experimental design consisted of three replicate plots for the helicopter application and three for the ground equipment. Each plot was 64 feet wide and 790 feet long. The six plots were adjacent to each other with the treatments alternating; a helicopter plot followed by a ground-spray plot, followed by another helicopter plot, and so on. One sugar beet variety was planted. The experimental area was chosen for its uniform topography, soil type and crop stand. One unsprayed

plot was located adjacent to the block of treated plots.

Results. Disease first appeared in mid-July, increasing slowly at first but finally reaching heavy proportions in the check plot by the first part of September. At harvest, disease incidence was rated: check=4; helicopter plots=2.5, 2, and 2.5, respectively; ground-equipment=1, 1.5, and 1.5, respectively. We used the disease rating scale of 0-5 established in the Kleinwanzlebener Cercospora Table.

Data on tons of sugar beets harvested, per cent sucrose, and per cent purity are presented in Table 1. Exactly 0.40 acre was harvested in the center of each plot. For sugar analysis, 2 lots of 8 beets were gathered at random from each harvested plot. The sucrose analyses were made through the cooperation of the American Crystal Sugar Company, Research Department, to whom we express our appreciation. The average sugar beet yields for the helicopter and the ground-equipment treatments are almost identical. The sprayed plots yielded an average of 2.4 tons of beets more than the unsprayed plot. The per cent sucrose data did not differ significantly (at 5% level) between the 2 treatments, even though the ground-equipment plots had a higher sucrose average. The per cent sucrose for the unsprayed plot was significantly lower than that for the sprayed plots. The average per cent purity data for the ground-spray treatment was significantly higher than the helicopter treatment or the check.

The total sugar per acre for the ground equipment was slightly higher (not significant) than the helicopter, both treatments yielded about 1,000 pounds more total sugar per acre than the check.

Discussion. Disease incidence was sufficient to test the effectiveness of the two spray methods. The disease epidemic in the test area during 1964 could be described as "moderate", because it started in mid-July and developed rather slowly at first. Under these conditions ground spraying was slightly better than helicopter spraying only in terms of per cent sucrose and per cent purities but not in tons of beets. Both spray methods were economically justified when compared to the unsprayed check. For example, four helicopter sprays may cost \$12-\$15; a 2.4 ton yield increase means about a 100% return above spray costs. Under a severe disease epidemic (one which starts early, builds up rapidly, and maintains itself until harvest) perhaps the ground spray may become significantly more effective than aerial spray; however, it is expected that either application method would give substantial increase in yields when compared to no spray.

Table 1. Yields from plots of sugar beets sprayed either by helicopter at 5 gallons per acre or by ground equipment at 40 gallons per acre.

Treatment	Rep. plot No.	Tons beets per acre (a)	Per cent sucrose (b)	Lbs. sugar per acre (c)	Per cent purity (b)
Ground Spray	1	13.56	14.2 14.0	3,824	87.6 89.2
	2	12.86	14.9 14.0	3,717	87.6 88.8
	3	12.80	13.7 13.8	3,520	88.1 85.9
	Average	13.07	14.1	3,687	87.8
	1	13.61	13.0 13.7	3,634	86.0 85.8
	2	13.32	13.5 12.3	3,437	85.9 86.9
Helicopter Spray	3	12.36	13.5 14.0	3,399	87.1 86.2
	Average	13.09	13.3	3,490	86.3
Unsprayed	1	10.66	11.9 11.7	2,516	85.0 85.2
	Average		11.8		84.6

a Tons of beets excluding the tare.

b Two samples of 8 beets each per plot.

c Average of the two sucrose samples multiplied by the pounds of beets per acre.

Attempt to Delay Leaf Spot Epidemic
by a Contact Fungicide

It is economically desirable to reduce the number of summer fungicide sprays needed to control leaf spot. Fewer sprays are needed when the disease appears late in the growing season. Theoretically, the onset of disease could be delayed by reducing the amount of primary inoculum in the vicinity of the sugar beet field. Sodium dinitro-ortho-cresylate (Elgetol) has been used as a dormant spray to destroy overwintering fungus inoculum in apple orchards, to reduce primary infections the following spring. Only limited success occurred with the control of apple scab; nevertheless, the dormant spray technique deserved a trial against sugar beet leaf spot. If one or two dormant sprays could delay onset of leaf spot the following summer by a month, one or two summer sprays could be eliminated. In some sugar beet areas it would be more convenient and economical to spray between harvest and planting time than to spray during the growing season. We studied whether one or two dormant sprays of Elgetol would delay onset of leaf spot the following summer.

Diseased sugar beet leaves remaining on a field after harvest are considered the major overwintering site of Cercospora beticola. In our treatment number one, the plots with leaves were sprayed soon after harvest and before fall plowing. In treatment number two, the plots were sprayed just before seedbed preparation in the spring. In treatment number three, the plots were sprayed twice; once in the fall and once in the spring. Unsprayed plots were included as a check. The spray rate on an acre basis was 2 gallons of Elgetol in 100 gallons of water.

Each treatment and the check were replicated on 3 plots, 14 by 15 feet each. A plot had eight rows of plants spaced 22 inches apart. The plots arranged in a random block design were separated from each other by 8-foot alleys kept free from plants. The experimental area had heavily diseased sugar beets the previous growing season. A 10-foot-wide, clean-cultivated strip surrounded the experimental area.

The experiment was replicated at two locations; the University of Minnesota Agricultural Experiment Station at Rosemount, Minnesota, and the American Crystal Sugar Company field research area at Mason City, Iowa. At Rosemount, there were no diseased sugar beet fields near the experiment. At Mason City by contrast the experiment was in an area surrounded by other plantings of sugar beets to determine whether the results would differ from those of the Rosemount location. Data were taken first when the disease appeared in each field and again about four weeks later. A rating scale of 0-5 was used with 5 representing heavily diseased plants with practically no green leaf growth. A total of 10 plants, 5 in each of 2 center rows, were rated per plot.

The data presented in Table 2 show no clear trend between treatments. The experimental results are negative, since the unsprayed checks had no more disease than the sprayed plots. Disease increased in all plots between the first and second observations. The results were

similar at the two locations; the presence or absence of other nearby sugar beet plantings did not affect the outcome of the experiment. The Mason City plots were planted one month before the Rosemount plots, which may account for the late appearance of disease at Rosemount.

The negative results are probably due to the chemical not killing sufficient inoculum in the leaf debris within each plot. The results could also be accounted for by a uniform inoculation of all plots from wind-blown spores originating from outside the experimental areas; however, this is not considered as likely as the former possibility. Apparently, a contact fungicide applied as a dormant spray is not effective in delaying the onset of disease during the following summer. These results parallel those obtained by earlier investigators with apple scab epidemics.

Table 2. Leaf spot rating of sugar beet plots sprayed with a contact fungicide (Elgetol) after harvest and before planting.

Treatment	Average leaf spot disease index ^{a/}			
	Rosemount		Mason City	
	^{b/} observation date		^{b/} observation date	
	8/4/64	9/4/64	7/6/64	7/28/64
Fall spray	0.3	1.3	0.2	1.7
Spring spray	0.3	1.4	0.2	1.6
Fall and Spring sprays	0.1	2.1	0.1	1.8
Unsprayed check	0.1	1.4	0.2	1.6

^{a/} Based on 10 plants in the center of each plot. Each rating is the average for 3 plots. 0=no disease, 5=maximum disease possible.

^{b/} First observation made when disease first appeared in the experimental area.

Controlled Environment Studies

Leaf Spot Incidence of Sugar Beet as Affected by Inoculum Concentration and Moisture Periods in a Controlled Environment

We need a reliable method for obtaining leaf spot on sugar beets under greenhouse or controlled environment conditions. This method would be useful for studying host-parasite relations, and possibly for screening disease resistance in new sugar beet varieties. In controlled environment chambers, we measured disease incidence as affected by three variables: inoculum concentration; duration that inoculated leaves were wet; duration between inoculating and observing.

Materials and Methods. The procedure had four steps: spore suspension prepared and applied to plants; inoculated plants exposed to continuous mist; plants incubated in the controlled environment chamber; and disease incidence measured.

The inoculum consisted of spores from cultures growing on beet leaf agar for 4-6 days at about 22° C under artificial light for 12 hours each day. Two petri dish cultures of each fungus isolate provided sufficient spores for each experiment. Spores were removed by adding about 5 ml of water to the culture, gently stroking the colony surface with a flat camel's-hair brush, and rinsing the colony with small amounts of water from a wash bottle. The water rinses containing the spores were pooled in a small beaker. The dark spore suspension at this stage contained appreciable amounts of nutrients that were subsequently removed by washing the spores in a Millipore microanalysis filter holder consisting of a 15 ml glass cylinder on top of a filter pad having pores 5 micra in diameter. The spore suspension was poured from the small beaker into the filter apparatus; the volume of the suspension was allowed to be reduced by suction to about 3 or 4 ml; more distilled water was added to bring the volume up to about 12 ml; and the process was repeated at least 5 times, resulting in a colorless spore suspension. While washing the spores they had to be suspended all the time, because if all the liquid went through the filter pad the long *Cercospora* spores would form a mat and not resuspend when water was added again. The spore suspension was then poured into a clean beaker and volume reconstituted to about 40 ml, using washings from the filter apparatus, which removed any spores clinging to the filter pad or glass cylinder.

Different spore concentrations were prepared by taking aliquants of the washed spore suspension and diluting them with sufficient distilled water to achieve required spore concentration which was checked by a hemacytometer.

Sugar beet plants were inoculated by means of a camel's-hair brush dipped in the appropriate spore suspension. Both surfaces of three tagged leaves on each plant were uniformly covered with the spore suspension. A trace of wetting agent in the suspension helped to distribute the spores over the surfaces of the inoculated leaves. The inoculated plants were then placed in a mist chamber that kept the leaf surfaces covered constantly with a film of moisture. After the appropriate period in the moist chamber, the sugar beet plants were moved to the

environment chamber whose 24-hour program consisted of 16 hours at 70°F, 60-65% relative humidity, plus 1,500 fc from fluorescent and incandescent lamps; then 8 hours at 60°F, 80-90% relative humidity, and no light.

Disease incidence was rated at 7, 14, 21, and 28 days after inoculation. Each inoculated leaf was rated as follows: 0 = no *Cercospora* spots, 1 = 1-10 spots, 2 = 11-20 spots, 3 = 21-50 spots, 4 = 51-100 spots, 5 = more than 100 spots. Each treatment was replicated on 9 leaves, i. e., 3 leaves per plant on 3 plants. Each datum in the tables is the average rating of nine leaves.

Results and Conclusions. Table 3 summarizes data from two replicate experiments in which 3 spore concentrations (320,000; 140,000; and 40,000 spores/ml) of one fungus isolate (Holland) were applied to one sugar beet variety (American 3S) and the plants kept in the mist chamber for either 0, 1, 2, or 4 days.

Disease incidence was influenced most by the duration in the mist chamber. Plants exposed 4 days showed abundant disease at the first observation, 7 days after inoculation. Plants not exposed to mist had no more than a trace of symptoms at any of the observations. The plants exposed to mist for 1 or 2 days gave intermediate results.

Duration between inoculation and observation was the second most important factor associated with disease incidence, particularly with plants in the mist chamber for 1 and 2 days. Number of *Cercospora* spots increased with each subsequent weekly observation. Inoculum concentration also produced differences in disease incidence, but generally these differences were smaller than those associated with the other two factors just mentioned. The greatest amount of leaf spotting in the shortest period of time occurred by exposing the plants to mist for 4 days and by using 140,000 spores or more per ml of suspension.

In the above experiment only one fungus isolate was used. Will other isolates behave similarly? Another experiment was done, using three fungus isolates (Holland, Iowa, Ohio) on the same sugar beet variety (American Crystal 3S). The spore concentration was kept constant; 170,000 spores/ml of suspension. The results are summarized in Table 4. Again we see a trend towards increasing disease incidence and shorter incubation periods as the plants were exposed to longer periods in the mist chamber, thereby supporting the conclusions from the earlier experiment. At 28 days most of the differences in results between fungus isolates were small.

So far only one sugar beet variety was tested. Will other varieties behave similarly? A further experiment was done with three sugar beet varieties inoculated with one fungus isolate (Holland) at one spore concentration (160,000 spores/ml of suspension). In the field, sugar beet variety 6122-0 is known to be resistant, variety 2269 is susceptible, and variety American Crystal 3S is intermediate. The results are summarized in Table 5. With increasing mist period the disease incidence increased and incubation period decreased. Variety 6122-0 consistently had less disease than the other two varieties when the plants were exposed to mist for 1, 2, or 4 days. Varieties 3S and 2269 did not show significant differences in disease on the plants misted for 1, 2, or 4 days. The results among the 0-day plants were anomalous.

All the experiments show that disease incidence is greatly influenced by the duration of the mist period. The time between inoculation and observation also affects disease incidence. The inoculum concentration can influence disease if the number of spores is much less than 140,000/ml of suspension; the higher concentration tested did not have a significant effect on disease incidence. With the aid of these findings heavy disease incidence is readily obtainable in a controlled environment.

Table 3. Leaf spot incidence resulting from three inoculum concentrations of one fungus isolate on one sugar beet variety subjected to varying durations in mist.^{a/}

Days in mist chamber	Days from inoculation to observation	Leaf spot incidence ^{b/} 10 ⁴ spores/ml		
		4	14	32
0	7	0	0	0
	14	0	0.1	0.2
	21	0	0.2	0.4
	28	0.3	0.4	0.8
1	7	0.1	0.1	0.1
	14	0.2	0.4	1.2
	21	0.9	1.7	2.6
	28	1.8	2.5	3.1
2	7	0.3	1.8	2.3
	14	1.3	3.1	3.5
	21	2.0	4.0 ^{c/}	4.3
	28	2.2	-	-
4	7	2.6	4.1	4.6
	14	3.6	4.6	4.8
	21	4.0	4.9	5.0
	28	-	-	-

^{a/} Fungus isolate, "Holland." Sugar beet variety, American 3S.

^{b/} Average rating for nine leaves. 0 = no spots; 1 = 1-10 spots; 2 = 11-20 spots; 3 = 21-50 spots; 4 = 50-100 spots; 5 = more than 100 spots per leaf.

^{c/} Leaves dead due to leaf spot. Not possible to read accurately.

Table 4. Leaf spot incidence from three fungus isolates inoculated at one spore concentration unto one sugar beet variety and subjected to various periods of mist. ^{a/}

Days in mist chamber	Days from incubation to observation	Leaf spot incidence ^{b/}		
		Fungus isolates		
		Holland	Iowa	Ohio
0	7	0	0	0
	14	0	0	0
	21	0.1	0	0
	28	0.1	0.4	0.3
1	7	0	0	0
	14	0	0	0
	21	1.0	2.0	2.0
	28	2.3	3.4	2.7
2	7	0	0	0
	14	0.6	0	0.6
	21	3.9	1.8	3.0
	28	4.2	3.5	4.3
4	7	1.4	0	0
	14	4.2	0.8	3.1
	21	5.0	4.0	4.9
	28	5.0	4.9	5.0

^{a/} 17×10^4 spores/ml. Sugar beet variety, American 3S.
^{b/} Same as for Table 3.

Table 5. Leaf spot incidence resulting on three sugar beet varieties inoculated with one spore concentration of one fungus isolate, and subjected to varying durations in mist. ^{a/}

Days in mist chamber	Days from inoculation to observation	Leaf spot incidence ^{b/}			
		Sugar beet varieties			
		Am 3S	2269	6122-0	
0	7	0	0	0	
	14	0	0.2	0	
	21	0.3	1.7	0.7	
	28	0.4	1.9	0.7	
1	7	0	0	0	
	14	1.2	0.8	0.4	
	21	2.8	2.4	1.2	
	28	3.3	3.1	1.9	
2	7	0	0	0	
	14	2.9	3.0	2.4	
	21	4.3	4.0	2.9	
	28	4.4	4.3	3.1	
4	7	2.3	1.9	1.2	
	14	4.6	4.6	3.7	
	21	4.8	4.8	4.1	
	28	4.8	5.0	4.1	

^{a/} 16×10^4 spores/ml. Fungus isolate, "Holland."

^{b/} Same as for Table 3.

Leaf Spot Resistance of Sugar Beet Varieties Measured in a
Controlled Environment and Compared with Field Data

At present all screening for leaf spot resistance in new sugar beet varieties is carried out in the field; a cumbersome and expensive method. Plant breeders need a technique which is relatively quick, reliable, and inexpensive. These advantages may possibly be obtained by screening seedlings in a controlled environment the year round. We measured leafspot incidence on 10 sugar beet varieties^{1/} growing in the greenhouse and controlled environment chamber. In the field, the disease reactions of the 10 varieties were already known and ranged from very susceptible to very resistant.

The washed spore suspensions were prepared as described in the preceding report. Two experiments were done. In the first experiment, the seedlings were 4 weeks old when inoculated with an equal mixture of spores from the Iowa and Ohio isolates of the fungus; total spore concentration was 160,000/ml of suspension. Both sides of 3 leaves per seedling were inoculated by means of a flat camel's-hair brush. There were 20 seedlings per variety which, following inoculation, were exposed to 2 days of continuous mist. Subsequently, four seedlings were moved to the greenhouse and six to the controlled environment chamber to determine the effect of both locations on disease incidence. Observations, based on the number of spots per plant, were made 1, 2, and 3 weeks after inoculation.

The second experiment was arranged similarly to the first, except for the following; 8-week-old plants were used, 3 plants per variety in the greenhouse and 3 in the environment chamber; equal number of spores from the Red River valley and Iowa fungus isolates, with a total concentration of 190,000 spores/ml of suspension.

Results of the first experiment are found in Table 6 together with a description of the 10 varieties and their field reactions. For ease of comparison the results are grouped into four categories: VR=very resistant, R=resistant, S=susceptible, and VS=very susceptible. No close correlation occurred between results from the field, on the one hand, and those from the greenhouse or environment chamber on the other hand. Results differed from one observation date to another as well as between greenhouse and environment chamber. The results of the second experiment are not presented in detail because they too showed inconsistencies similar to those found in the first experiment. No consistent pattern of resistance or susceptibility existed between the two experiments or between the experiments and the field data. The screening method at the present stage of development is unreliable for use by plant breeders.

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Supplied by the American Crystal Sugar Co., Rocky Ford, Colorado

Table 6. Leaf spot reaction of 10 sugar beet varieties growing in the greenhouse and controlled environment chamber, compared with the disease reaction in the field.

Sugar beet variety ^b	Field ^b	Leaf spot rating ^a					
		Greenhouse			Environment chamber		
		Observation day ^c			Observation day ^c		
		7	14	21	7	14	21
SP 5822-0	VR	VR	VR	R	VR	VR	VR
Am. 3S	R	VS	S	S	VR	R	VR
US 401 (4n)	R	R	S	S	S	VS	VS
63-415	R	R	R	R	VR	VR	VR
62-604-0	R	VR	R	S	R	R	S
59-415-0	S	R	R	R	S	R	R
60-806-0	S	S	VS	VS	S	S	S
63-804	S	R	S	S	S	S	S
Am. 3N	VS	S	S	S	S	R	S
63-609	VS	VS	S	VS	VS	VS	VS

^aVR=very resistant. R=resistant. S=susceptible. VS=very susceptible.

^bSupplied by the American Crystal Sugar Co., Rocky Ford, Colorado.

^cNumber of days after the plants were inoculated.

Laboratory Studies

Sporulation of the Pathogen in Culture Affected by a Light and Temperature Reaction

Cercospora beticola may sporulate in culture; however, the physiological factors involved are not understood. We found recently that the combined effects of light and temperature significantly alter the number of spores formed. We measured sporulation of the fungus when grown in constant light, alternate light and darkness, and constant darkness at 15, 22.5, and 30°C.

Materials and Methods.--Single-spore isolates of C. beticola from Holland, Ohio, and Iowa were used. The three isolates were cultured continuously on agar for less than 1 year; they were pathogenic and appeared typical of other cultured isolates of this species. The medium consisted of sugarbeet molasses 150g, agar 1.5g, and distilled water 1 L. Our earlier trials showed this medium to be one of several which favored sporulation of C. beticola. The volume of medium was kept constant at 25 ml per 9-cm petri dish. The agar plates were uniformly inoculated with 1 ml of spore suspension obtained from one stock culture shaken vigorously in 50 ml of sterile distilled water. The inoculation resulted in uniform, rapid growth over the entire agar surface in the petri dish.

Light, darkness, and temperature were controlled in three constant temperature cabinets. Light was provided in three of the cabinets by a General Electric 40-watt incandescent appliance bulb no. 40A15 whose energy emission was mostly in the infrared region, while in the visible region intensity decreased steadily from the far red to the violet and ended with a trace in the near ultraviolet. The light bulb was 25-33 cm above the cultures and gave an intensity of 55 to 85 fc through the petri dish cover. Light intensity was measured by means of a General Electric light meter model 213 containing a correction light filter. The quality and intensity of light approximated that which could normally occur in a laboratory. Darkness in the cabinet with no light bulb was checked with a photocell which showed no response even at its lower limit of sensitivity of approximately 1/250 fc. In the cabinet with alternate light and darkness, the bulb was turned on and off by an automatic timer. The temperature of each cabinet was controlled within ± 1.0 C by a combination of heating and cooling units, built-in blower, and ducts. A thermograph was placed in each cabinet on the same shelf as the fungus cultures to record the temperature during the experiment.

The treatments were: a) constant light, b) constant darkness, and c) alternate light (12 hours) and darkness (12 hours), carried out at 15, 22.5, and 30°C. Replications included: three experiments with the Holland isolate and two with the Iowa and Ohio isolates at each temperature. Five replicate plates of each isolate were used per treatment. Statistical analysis of spore count and dry weight data involved the F-test and multiple range test. "Significant" in this paper refers to the 5% level.

Sporulation and colonial growth were measured after the cultures were incubated for 7 days in the constant temperature cabinet. A spore suspension from each plate was prepared by cutting out a uniform disc (2.54 cm²) of colony, placing it in 10 ml water, and agitating the mixture for one minute. At least six spore counts were made from each spore suspension

by means of a hemacytometer. The number of spores obtained from 1cm^2 of colony surface was calculated. Colonial growth was measured as dry weight by lifting the remaining mycelial mat and agar from each culture plate; floating the mat for 1 minute on boiling water to melt the agar; then placing the mat on a weighed 9-cm filter paper and drying for at least 48 hours in a 70°C oven. The dried mycelial pads were then cooled in a desiccator and weighed to the nearest 0.1 mg.

Results. Light is associated with heat. In radiation experiments the temperature inside the culture dishes must not increase above the desired level. This possibility was examined by measuring the temperature with a thermocouple placed inside closed Petri dish cultures exposed to constant light. No increase in temperature occurred above that outside of the culture dish. Therefore, the effects described in the present experiments are due to the light treatments.

Sporulation. Light and temperature interacted to affect sporulation as shown in Figure 1. At 15°C both alternate light-darkness and constant light significantly stimulated sporulation when compared to constant darkness.

At 22.5°C alternate light-darkness significantly stimulated sporulation over both constant light and constant darkness treatments. The relationship between the latter two treatments varied among the isolates. With Ohio, constant light stimulated sporulation over constant darkness; with Holland, constant light depressed sporulation; and with Iowa, no significant difference occurred between the two treatments.

At 30°C alternate light-darkness and constant light depressed sporulation when compared to the dark treatment. Constant light gave the least sporulation. The differences between the three treatments were significant, except for Holland at 30°C .

Maximum sporulation occurred under constant or alternating light at 15°C for the Holland and Iowa isolates, and under alternating light at 22.5°C for the Ohio isolate. Minimum sporulation occurred under constant light at 30°C for all 3 isolates. Innate differences for sporulation probably exist among the isolates, since Iowa outproduced the other 2 isolates at 15 and 30°C .

Growth. The dry weights of the mycelial mats are presented in Table 7. No significant difference occurred between the light or dark treatments within a given temperature and isolate, except for Holland at 15°C , where constant dark resulted in significantly less growth than the two light treatments. These results suggest that light, with the exception just noted, did not affect growth.

Growth varied among the three isolates, Ohio having more growth at 22.5 and 30°C than the other two isolates. Growth also varied according to temperature, tending to be maximum at 22.5°C and minimum at 30°C for each isolate.

Discussion. The response to light may be general for the entire species. The present study included only 3 isolates but these came from widely separated origins (Europe and North America) suggesting that many sporulating isolates will be affected by light.

Our data show that some isolates of *C. beticola* can: 1) produce more than 1,000,000 spores/ cm^2 of colony surface, and 2) sporulate best at temperatures under 22.5°C .

Table 7. Dry weight of Cercospora beticola cultures growing either under constant light, alternate light and darkness, or constant darkness at three temperatures.

Isolate	Treatment ^{b/}	Grams dry weight of fungus cultures ^{a/}		
		15°	22.5°C	30°C
Holland	L	0.8390	0.8082	0.6172
	L/D	0.8026	0.7629	0.6516
	D	0.4241	0.7694	0.5839
Iowa	L	0.5599	0.7932	0.5324
	L/D	0.5605	0.7550	0.5567
	D	0.6117	0.6979	0.5210
Ohio	L	0.7191	0.9161	0.7696
	L/D	0.7023	0.9725	0.8426
	D	0.6066	0.9205	0.7137

^{a/} Each number is the average dry weight of 10-15 replicate cultures. No statistically significant differences occurred within each block of 3 numbers except for Holland at 15°C where treatment D had significantly less weight than L or L/D.

^{b/} L=constant light. L/D=alternate light (12 hrs) and darkness (12 hrs). D=constant darkness. Experiments lasted 7 days.

The growth data with one exception (Holland at 15°C) showed that dry weights of colonies for a given temperature and isolate were statistically similar, while spore numbers differed significantly. This suggests that light directly affected sporulation but not vegetative growth.

Sporulation of C. beticola in vitro is affected by more factors than light and temperature. For example, the genetic capacity to form spores must be present in an isolate, and an appropriate medium must be used. Further studies are needed to clarify all the factors controlling spore formation in this fungus species. The present work shows that light stimulates sporulation of C. beticola cultures at 15 and usually at 22.5°C, and depresses sporulation at 30°C.

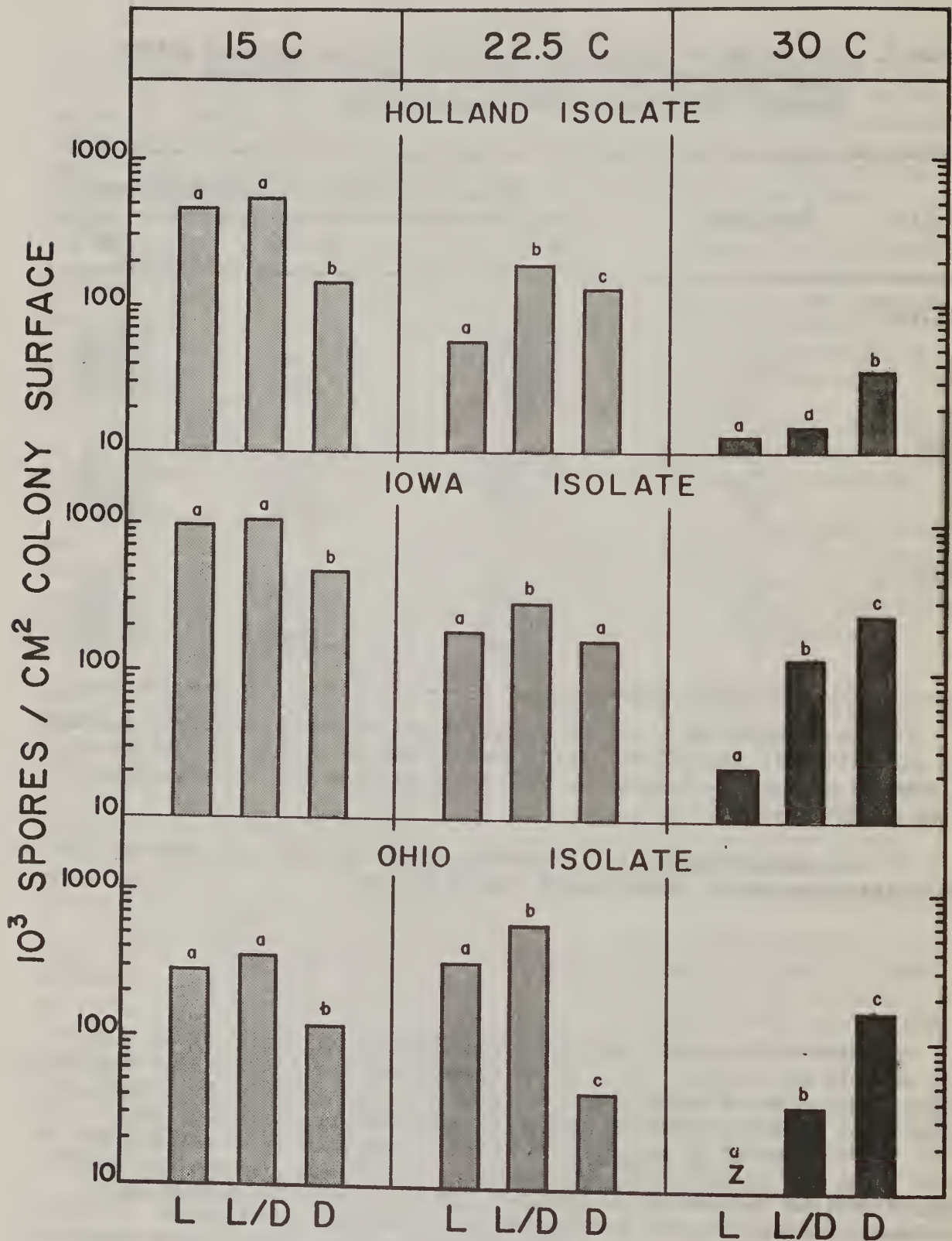


Figure 1.--Sporulation of three isolates of *Cercospora beticola* exposed for 7 days to constant light (L), alternate light and dark periods of 12 hours each (L/D), and constant darkness (D) at 15, 22.5, and 30°C. Within each group of three bars, similar letters above the bars indicate no statistical differences. Z (Ohio isolate at 30°C) indicates a low value of 2×10^3 spores.

P A R T XI

STUDIES ON SUGARBEET SEEDLING DISEASES

D. L. Mumford

Research conducted in cooperation with Michigan
Agricultural Experiment Station.

STUDIES ON SOILBORNE FUNGUS PATHOGENS OF SUGARBEET SEEDLINGS

David L. Mumford

Rapid Identification of Soilborne Fungus Pathogens of Sugarbeet Seedlings

There are several fungi that attack sugarbeets during the early stages of seedling development. Although symptoms caused by an individual pathogen are sometimes characteristic enough for identification by an experienced observer, ordinarily it is difficult to determine the pathogen involved simply by observing diseased seedlings. Frequently, more than one pathogen infects the seedlings, which increases this difficulty.

Soilborne fungi infecting sugarbeet seedlings can be identified rapidly and with minimum effort simply by incubating all or part of the infected seedlings in water and examining them with low magnification. This is not a new method of identifying fungus pathogens of plants, but it is a convenient method. Commonly the fungi causing seedling diseases are identified by culturing and isolating them, using regular or selective solid media. This requires considerable time and is less than satisfactory when several pathogens are involved. If only an identification of the pathogens is desired, this can be accomplished with reasonable accuracy in 24-36 hours after placing infected host tissue in water at room temperature.

Five fungus pathogens of sugarbeet seedlings are illustrated here. The illustrations are all of low magnification (30x) and show each fungus growing from an infected hypocotyl of a sugarbeet seedling in water. Each fungus has a characteristic growth habit in water and, with one exception, usually produces distinct reproductive structures. With proper illustrations of these characteristics as a guide, an untrained observer can usually identify these pathogens. (Figures 1 to 5, inclusive.)

Analysis of Soil Samples for Fungus Pathogens of Sugarbeet Seedlings

A combination of the identification procedure described above and a plant infection test similar to that used for determining root rot potential of pea fields (2) was employed in some preliminary testing of sugarbeet fields in Michigan. The purpose of this work was to evaluate the overall procedure and to obtain information on the kinds and relative importance of soilborne fungus pathogens of sugarbeet seedlings.

Procedure: Soil samples from 20 sugarbeet fields were tested. Ten soil samples were obtained from fields in the area of Bay City, Michigan, while the other 10 were from rotation plots at the Ferden Farm near Oakley, Michigan. Cropping sequences at this farm are carried out by the Soil Science Department of Michigan State University in cooperation with the Farmers and Manufacturers Beet Sugar Association. Two soil samples were taken from each of 5 rotations, 1 from a plot receiving high fertilization, and 1 from a plot receiving low fertilization. A key to the rotations is given in Table 1.

Table 1. Seedling infection test of soil samples for fungus pathogens of sugarbeet seedlings.

Sample number	1963 Crop	No. seedlings infected of 25 examined			No. seedlings uninfected
		Aphanomyces	Phythium	Rhizoctonia	
1	Beans	1	14	0	10
2	Wheat	6	9	0	11
3	Beans	7	14	1	6
4	Wheat	14	7	0	5
5	Beans	1	17	0	7
6	wheat	16	12	0	2
7	Beans	12	11	1	2
8	Beets	1	7	0	17
9	Beans	2	20	0	3
10	Beans	5	17	0	5
11	a/	25	2	0	0
12	"	25	5	0	0
13	"	19	16	0	1
14	"	17	6	1	5
15	"	20	3	0	5
16	"	12	2	0	12
17	"	14	7	0	6
18	"	16	16	0	2
19	"	13	13	0	5
20	"	11	19	0	1

a/ Rotation sequences for plots sampled from Ferden Farm

Sample number	Rotation
11 and 12	Barley, alfalfa, alfalfa, beans, beets
13 and 14	Corn, beans, wheat, sweet clover, beets
15 and 16	Soybeans, wheat, sweet clover, beans, beets
17 and 18	Barley, beans, wheat, corn, beets
19 and 20	Continuous beets. Sample 20 was taken from a local area showing severe seedling disease symptoms.
(Plots 11, 13, 15, and 17 received $\frac{1}{4}$ the fertilizer rate of plots 12, 14, 16, and 18.)	

REFERENCES

- McKeen, W. E., 1949. "A Study of Sugarbeet Rootrot in Southern Ontario," Canadian Journal of Research, 27 : 284-311.
- Sherwood, R. T., and D. J. Hagedorn, 1958. "Determining Common Root Rot Potential of Pea Fields," Wisconsin Agricultural Experiment Station Bulletin 531, 12 p.

Soil samples were collected with a soil probe. Two probes 5-6 inches deep were taken from each of 20 locations per field. The soil from 40 probes was placed in large polyethylene bags and constituted the sample from the field. Within 1-2 days following sampling, the soil from each field was mixed thoroughly on a clean newspaper then transferred to 5 sterile 6-inch clay saucers. Two seeds of a susceptible variety were planted in each of 7 locations in each saucer. Saucers were kept at a temperature of about 75° F. and watered normally until emergence (4 days), after which they were heavily watered until removed for examination.

Eight days after planting, 5 seedlings were removed from each saucer; 1 from each of 5 of the 7 planting locations in the saucer. All seedlings were thoroughly washed and placed in petri dishes containing tap water. Twenty-four to 36 hours later the seedlings were examined microscopically for fungus pathogens.

Results and Conclusions: The data in Table 1 indicate that Aphanomyces cochlioides and Pythium ultimum were the predominant pathogens in the soil samples tested. Both pathogens were frequently found infecting the same seedling. This explains the occurrence, in Table 1, of sample numbers with data of both Aphanomyces and Pythium totaling more than 25. The absence of Pythium aphanidermatum and Fusarium sp. and the infrequency of Rhizoctonia solani are not readily explainable. It has been repeatedly observed that injured seedlings taken directly from the field, such as those from wind damaged areas, are more frequently infected with Fusarium and Rhizoctonia. The seedlings examined in this study received little or no injury during the time they were exposed to the fungi. McKeen (1) found P. aphanidermatum only in more sandy soils. This may account for its absence in these tests, where only clay soils were used.

Fertilization level did not consistently alter pathogenic flora of soils in these tests. Rotation sequence seemed to have an effect. For example, twice as many seedlings were infected with Aphanomyces in samples 11 and 12 as in 19 and 20. On the other hand, the data indicate the level of Pythium was low in samples 11 and 12 and relatively high in 19 and 20.

Improvement of this method of analysis might make it a useful tool in obtaining information on soilborne fungus pathogens of sugarbeet, including some measure of the relative importance of each. In this connection it may be used to identify fields with high disease potential where planting should be avoided. The method should be tested further, possibly with artificially inoculated soils, to determine the degree of accuracy that can be obtained in separating soils in which the pathogenic flora differs.



Figure 1. Aphanomyces cochlioides. Note clusters of encysted zoospores at the end of evacuation tubes.

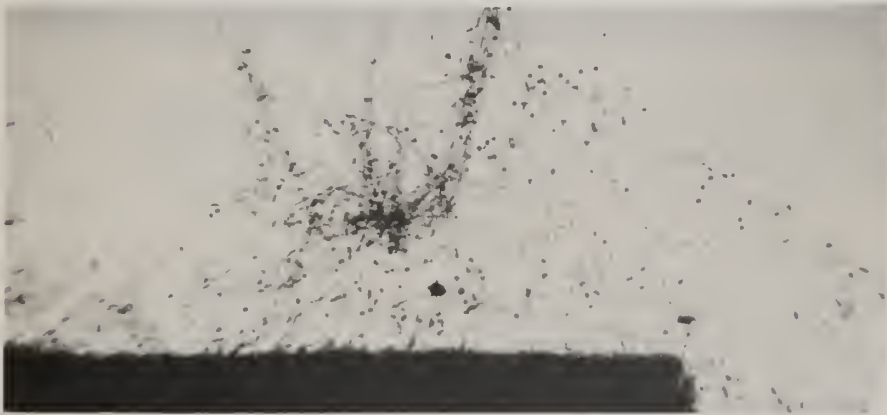


Figure 2. Pythium ultimum. Note the fine mycelial strands and numerous round sporangia.



Figure 3. Pythium aphanidermatum. Note irregular shaped, finger-like sporangia (arrows) at ends of branches.



Figure 4. Rhizoctonia solani. Note coarse mycelial strands and tendency for branches to arise at right angles. Also, the mycelial strands of this fungus commonly grow to the surface of the water.



Figure 5. Fusarium sp. Note dense growth of mycelium. Although not shown, this fungus often produces crescent-shaped spores.

P A R T XII

PHYSIOLOGICAL INVESTIGATIONS

- - -

QUALITY

F. W. Snyder

Research conducted in cooperation with Michigan Agricultural
Experiment Station.

PHYSIOLOGICAL INVESTIGATIONS - 1964 ¹/₋

F. W. Snyder

Germination Studies 2/

ABSTRACT: The effect of ripeness per se on speed and percentage germination of seeds has been determined for fruits harvested at five-day intervals from the same plants. The data indicate that the latitude in date of harvesting for high quality seed is very limited.

The degree of ripeness of the fruit markedly influences the percentage of water absorbed by the dry fruit. Less mature fruits absorb more water. Also, soaking the fruits in hydrogen peroxide (0.1%) or water, followed by complete air drying, greatly reduces the amount of water absorbed by the immature fruits. The more mature fruits exhibit a similar pattern but much smaller in magnitude. Processed fruits of the same maturities absorb less water than whole fruits, but they follow the same patterns of water absorption as the whole fruits.

Processing of immature fruits increased the percentage of germination more than processing of mature fruits.

An experiment was designed to assess as precisely as possible the effect of ripeness on germination performance. The plants were marked and a branch was harvested at five-day intervals from each plant by A. A. Mast in Arizona. If available, 50 fruits of each size class for each date of harvest were placed on two layers of moist blotters in a germinator at approximately 70° F. Counts were made daily for ten days, and for some a 12-day count also was made. Germination data for the 13 plants of variety AI 1 x AI 2 are summarized in Table 1.

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- 1/ Research conducted in cooperation with Michigan Agricultural Experiment Station.
- 2/ Samples of seed were supplied by West Coast Beet Seed Company, Western Seed Production Corporation, and Farmers and Manufacturers Beet Sugar Association.

Table 1. Effect of time of harvest on the 10-day germination performance of seeds from 13 plants of variety AI x AI 2.

<u>Days of harvests</u>	<u>Fruit size* Inches/64</u>	<u>No. fruits tested</u>	<u>Percent of good seeds</u>	<u>Percent of good seeds germinated in 10 days</u>
-10	12	406	99.5	76.2
	10	604	97.5	58.1
	8	648	91.7	50.0
	7	596	73.8	50.5
	6	449	50.3	54.9
-5	12	560	99.3	91.9
	10	650	95.7	85.2
	8	648	81.8	76.4
	7	473	64.7	65.4
	6	237	42.6	57.4
0	12	626	98.6	94.3
	10	648	92.0	92.3
	8	644	74.4	78.9
	7	482	57.5	69.0
	6	340	34.7	72.9

* Unprocessed fruits sized with a series of round-hole screens. Fruits tested remained on the screen size indicated.

Table 2. Effect of ripeness on speed of germination of seeds from 13 plants of sugarbeet variety AI 1 x AI 2.

<u>Days of harvests</u>	<u>Percentages of germination in 5 days by fruit size classes*</u>				
	<u>12/64</u>	<u>10/64</u>	<u>8/64</u>	<u>7/64</u>	<u>6/64</u>
-10	44.2	52.6	55.2	48.2	53.2
-5	50.7	67.2	70.6	61.5	65.5
0	61.5	81.6	81.5	69.6	55.8

* Unprocessed fruits remaining on round hole screens. Percentages calculated on number of seeds that germinated in 10 days.

The fruits used in this study were described by A. A. Mast as commercially mature and ready for harvest at "O" harvest. The larger fruits on many of the plants were not fully straw colored according to the scale of ripeness used by Snyder in previous communications. The three smaller size classes of fruits generally were not straw colored at any of the times of harvest. The data seem to indicate clearly for this variety that five days in time of harvest may alter the percentage germination appreciably for the larger sizes of fruits which usually mature earlier than the smaller fruits. With the range in time of blooming of varieties that do not bolt uniformly, a 10-day differential may occur for a number of plants. The adverse effect of immaturity thus could depress percentage germination sharply.

The trend toward smaller percentages of good seeds (Column 4, Table 1) as the fruits approach maturity seems to be clear. This may be anomalous, but if it is true, its cause should be sought. The relatively lower percentages of good seeds in the two smaller size classes are partially caused by the inclusion of some chaffy fruits that could not be distinguished from small developed fruits.

The detrimental effect of immaturity on speed of germination is shown in Table 2. At five days the seeds in the intermediate-size fruits germinated more rapidly. Seeds in larger fruits germinate slower, but more completely, as shown in Table 1. The seeds in the smaller fruits germinate more slowly than the seeds in the intermediate fruits, largely because they are more immature than the seeds in the intermediate fruits. (Earlier data¹ on seeds in mature, straw-colored, small fruits did not follow this pattern.) The 12-day germination percentages increased more for the seeds in the less mature fruits than for those in the more mature fruits, thus indicating that the less mature seeds required a longer time to determine their full germination potential. Seeds from ten plants of variety GW 823 that were harvested by A. A. Mast at the same time as those of variety AI 1 x AI 2 revealed similar effects of ripeness on speed and percentage germination.

The degree of ripeness of the fruit so markedly affected water absorption that during germination counts the wetness of the green fruits was observed to be much greater. They glistened and even accumulated droplets of water on the upper surface of the fruits. A quantitative measure of the difference in water absorption between ripe (straw-colored) and immature or greenish-colored fruits was made on whole and hand-processed fruits. Also, the effect of soaking the fruits in water or 0.1% hydrogen peroxide for three hours, followed by complete air drying, was compared with that of the unsoaked dried fruits. The weighed fruits were placed on two layers of moist blotters in a germinator at approximately 70° F. for 48 hours and then weighed again. The data (Table 3) indicate clearly the significant differences. Apparently some water soluble substance, which affects water absorption in fruits harvested before maturity, is altered as maturity progresses.

¹ Hogaboam, G.J. and Snyder, F.W. "Influence of Size of Fruit and Seed on Germination of a Monogerm Sugarbeet Variety" American Society of Sugar Beet Technologists Journal, 13(2).

Table 3. Effect of ripeness and soaking followed by drying on water uptake by sugarbeet fruits. (SL 129 x 133)ms x 5822-0.

Harvest	Fruit	Percentage increase in weight in 48 hrs. for		
		Dry	H ₂ O ₂ soaked	H ₂ O soaked
18 days early	Whole	160.6*	89.3	80.4
	Processed	102.6	72.7	75.3
3 days early	Whole	81.0	56.3	54.4
	Processed	49.6	42.4	43.6

* All percentages expressed as $\frac{\text{Wet wt.} - \text{air dry wt.}}{\text{Air dry wt.}}$

Table 4. Effect of hand-processing of fruits of three maturities on percentage germination of variety AI 1 x AI 2.

Fruit size-class*	Percentages of seeds germinated in 10 days by days of harvest					
	-10		-5		0	
	Whole	Processed	Whole	Processed	Whole	Processed
12/64	84	100	88	99	96	100
10/64	49	90	81	96	90	98
8/64	31	64	77	91	82	86
7/64	57	75	-	-	-	-

* Sized whole fruits with a series of round-hole screens.

Table 5. Effect of nitrogen fertilization on volumes of taproots leaves, and crowns of variety SL 126 x SP 5460-0.

Lbs. N/A	No. of Plants	Average volume of			Root Shoot	Crown as percent of root
		Root	Crown	Crown + leaves (shoot)		
30	45	6.05	0.89	2.96	2.04	14.7
180	43	6.97	1.68	4.60	1.52	24.1

Processing of the immature fruits improved the percentage of germination sufficiently to give acceptable germination (Table 4). Because of the lower germination of the more immature seeds, the improvement was greater than for the more mature seeds.

Quality Studies

Cooperative studies involving Michigan Sugar Company, Monitor Division, Farmers and Manufacturers Beet Sugar Association, Michigan State University, and USDA have proceeded in a number of directions. The root-shoot ratio and proportion of crown to root affect both yield and quality. Hogaboam and Snyder have developed a method of measuring root, crown, and leaf volumes by volumetric water displacement. The effect of rates of nitrogen fertilization on a variety is indicated in Table 5. The proportion of crown was increased by higher nitrogen fertilization.

Variations in the percentage of crown tissue were determined for the Hayward Farm variety test, Bay City. Ten-beet samples from each of the plots of the 8 x 8 test were harvested with the crown attached, washed, weighed, decrowned in the tare-room decrowning machine, and reweighed. The average percentages of crown varied between 12.6 and 18.7. Six varieties varied between 14.1 and 16.4 percent. The differences were highly significant (F-value 6.47, F-value for 1% about 3.2).

The role of fertilization, especially nitrogen, has been studied in 1962, 1963, and 1964. Results have been consistent for the three years. Data for 1964 are summarized for two tests (Table 6). The relatively low level of nitrogen needed for high tonnage is noteworthy. The addition of nitrogen adversely affected quality and seriously depressed recoverable sugar. The amounts of the impurities in the clear or thin juice were closely related to clear juice purity (Table 7).

Table 6. Effect of nitrogen on yield and quality of sugarbeets grown near Bay City, Michigan. Variety SL 126ms x SP 5460-0.

APPOLD NITROGEN TEST

<u>Total N*</u> <u>per Acre</u>	<u>Beets/</u> <u>100 Ft.</u>	<u>Wt.***</u> <u>T/A</u>	<u>Sugar</u> <u>%</u>	<u>CJP</u> <u>%</u>	<u>Gross</u> <u>Sug./A</u>	<u>Recov.</u> <u>Sug./A</u>	<u>%</u> <u>Recov.</u>	<u>Recov.</u> <u>Sug./T</u>
30	87	20.26	16.27	93.61	6593	5733	86.96	283.0
60	87	22.50	16.20	93.06	7290	6267	85.97	278.6
90	86	23.06	15.82	92.62	7296	6207	85.07	269.1
120	88	20.72	15.15	92.23	6278	5293	84.31	255.4
150	87	22.78	15.07	92.25	6866	5786	84.27	254.0
190	86	21.66	14.12	90.53	6117	4942	80.79	228.2

WALRAVEN NITROGEN TEST

<u>Total N*</u> <u>per Acre</u>	<u>Beets/</u> <u>100 Ft.</u>	<u>Wt.***</u> <u>T/A</u>	<u>Sugar</u> <u>%</u>	<u>CJP</u> <u>%</u>	<u>Gross</u> <u>Sug./A</u>	<u>Recov.</u> <u>Sug./A</u>	<u>%</u> <u>Recov.</u>	<u>Recov.</u> <u>Sug./T</u>
30	94	25.58	17.17	93.97	8784	7703	87.69	301.2
60	93	24.92	16.73	93.22	8338	7203	86.39	289.0
90	94	24.83	16.45	92.05	8169	6872	84.12	276.8
120	92	25.48	16.70	92.17	8510	7182	84.39	281.8
150	93	25.02	15.62	90.10	7816	6275	80.28	250.8
190	97	25.39	15.68	90.35	7962	6424	80.68	253.0
230	89	25.76	14.62	88.40	7532	5765	76.54	223.8

* 30 lbs. at planting time, rest as side dress.

**Corrected for estimated 8% tare.

***Corrected for 5% tare.

Table 7. Impurity values* for the two nitrogen fertilization experimental tests of Table 6.

Lbs. nitrogen per Acre	Impurity values for each impurity by location					
	Amino nitrogen		Potassium		Sodium	
	Appold	Walraven	Appold	Walraven	Appold	Walraven
30	1169	2412	2496	2331	264	244
60	1614	2852	2733	2810	381	247
90	1681	3740	3005	2781	477	248
120	1615	3277	3095	3034	484	248
150	2463	5253	2748	3290	598	263
190	2781	4640	3608	2958	731	270
230	-	6082	-	3508	-	301

*Based on averages of 3 replications and calculated by method of Carruthers and Oldfield. Analyses made on clear juice.

P A R T XIII

DEVELOPMENT OF BASIC BREEDING MATERIAL AND
EXPERIMENTAL HYBRIDS FOR THE GREAT LAKES REGION

- - - - -

INHERITANCE OF MONOGERMNESS AND RESISTANCE
TO LEAF SPOT AND BLACK ROOT

Foundation Project 26

G. E. Coe

DEVELOPMENT OF BREEDING MATERIAL RESISTANT TO LEAF SPOT AND BLACK ROOT

G. E. Coe

Research under Foundation Project 26, at the Plant Industry Station, Beltsville, Maryland, is directed mainly toward varietal improvement in resistance to *Cercospora* leaf spot and *Aphanomyces* black root. From this program emanate parental lines for the production of hybrids and varieties evaluated in field tests reported in Part IV, 1964 Report.

This part of the Report will cover trends in the performance of basic breeding material, leaf spot tests of some experimental hybrids, and some new breeding lines that have been developed.

Improvement in Basic Breeding Stocks

The trends of the basic breeding stocks in disease resistance and in agronomic characteristics, as compared to the performance of US 401, are presented in graph form. Graphs 1 thru 8 provide comparison of the performance of US 401 with the average performance of all the multigerm and monogerm breeding lines tested. The performance of US 401 was arbitrarily given a numerical value of 100 each year for each characteristic investigated. Ratings higher than 100 indicate that the performance of the breeding lines was better than that of US 401; ratings less than 100 indicate that the breeding lines did not perform as well as US 401. In percentage soluble nonsugar solids, a rating greater than 100 indicates a lower percentage of soluble nonsugar solids than for US 401, and hence better performance with respect to this characteristic.

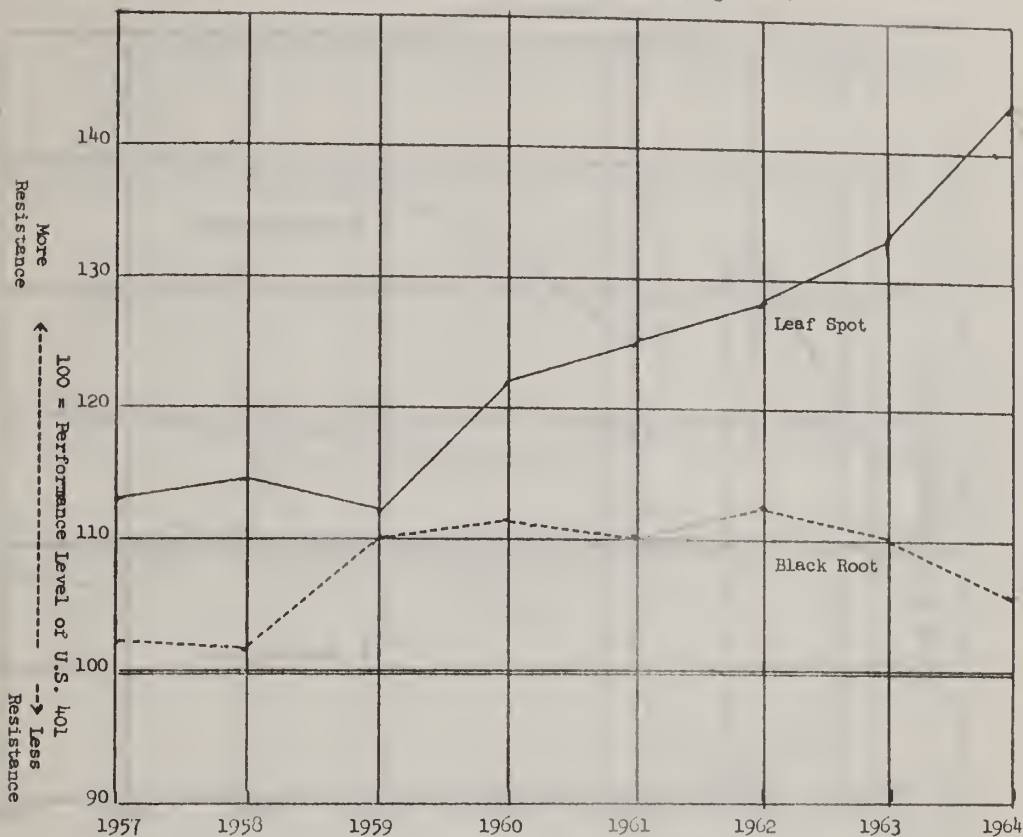
The 1964 nursery tests indicate good improvement in resistance to leaf spot for both multigerm and monogerm breeding material (Graphs 1 and 2), but no improvement, or perhaps even a slight decline, in resistance to black root. The failure to realize improvement in resistance to black root can best be explained as a decline resulting from heavy selection pressure for resistance to leaf spot. It is an accepted fact among plant breeders that when heavy selection pressure is applied to achieve a particular desirable characteristic there is usually (although not always) a decline in other desirable characteristics for which the plant breeder has been selecting. In the breeding program at Beltsville, sugarbeet progenies are first tested in the greenhouse for resistance to black root. Those with a satisfactory level of tolerance are then tested in the nursery for resistance to leaf spot. The root selections from the nursery plot stress resistance to leaf spot, and evidently most of the selected roots had less resistance to black root than their parent lines.

Since the breeding material did not improve in black root resistance, the greenhouse black root testing procedures were suspected of being rather ineffective. Therefore, a survey was made to determine whether progenies of plants selected from the greenhouse test were more resistant to black root than progenies of plants selected from the leaf spot nursery. The average performance rating of progenies of multigerm plants selected from the black root tests was 115; for the progenies of monogerm plants it was 113. It was concluded that the progenies of these selections were appreciably more resistant than the progenies of plants selected from the leaf spot nursery. Therefore, in the greenhouse black root test it was possible to eliminate the least resistant plants, while selections from the leaf spot nursery were at least indiscriminate with respect to black root resistance.

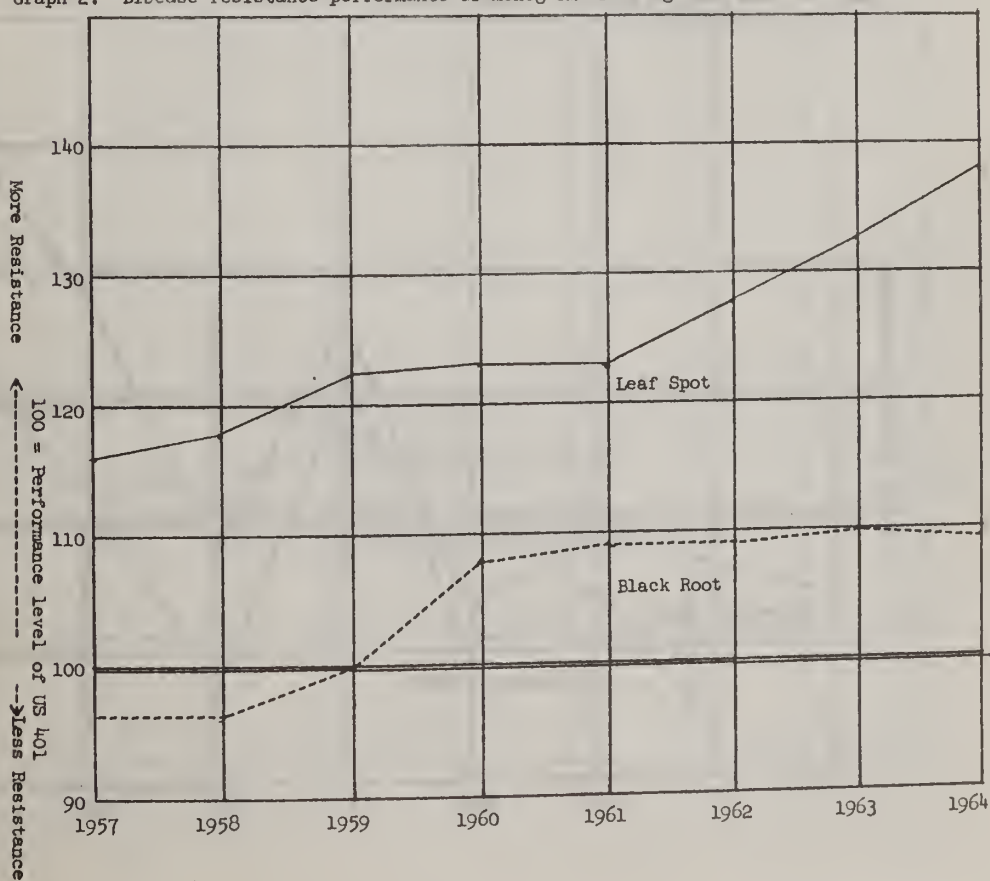
The leaf spot epidemic in the Beltsville nursery in 1964 was not as severe as in previous years; consequently, US 401 performed relatively better than it did in the past. This could account for the apparent performance decline of the multigerm breeding lines at Beltsville in root yield (Graph 3), percent sugar (Graph 5), and percent soluble nonsugar solids (Graph 7). The East Lansing nursery test in 1964 indicated no such decline. Although there was no increase in root yield in the multigerm lines at East Lansing (Graph 3), nor much improvement in sugar percentage (Graph 5), the performance with respect to soluble nonsugar solids was encouraging (Graph 7).

The improvement in root yield (Graph 4) and soluble nonsugar solids (Graph 8) of the monogerm lines is apparent for both Beltsville and East Lansing, but there was no appreciable change in percent sucrose (Graph 6). It is noteworthy that at both nurseries the monogerm breeding lines were about as good as the multigerm breeding lines in root yield and sugar percentage. It is also noteworthy that the performance with respect to soluble nonsugar solids in the monogerm lines has improved. They now equal US 401 in this characteristic but are still below the performance level of the multigerm breeding lines. From this monogerm material, it should be possible to obtain leaf spot resistant O-types having better combining ability than the previous monogerm O-types from Beltsville.

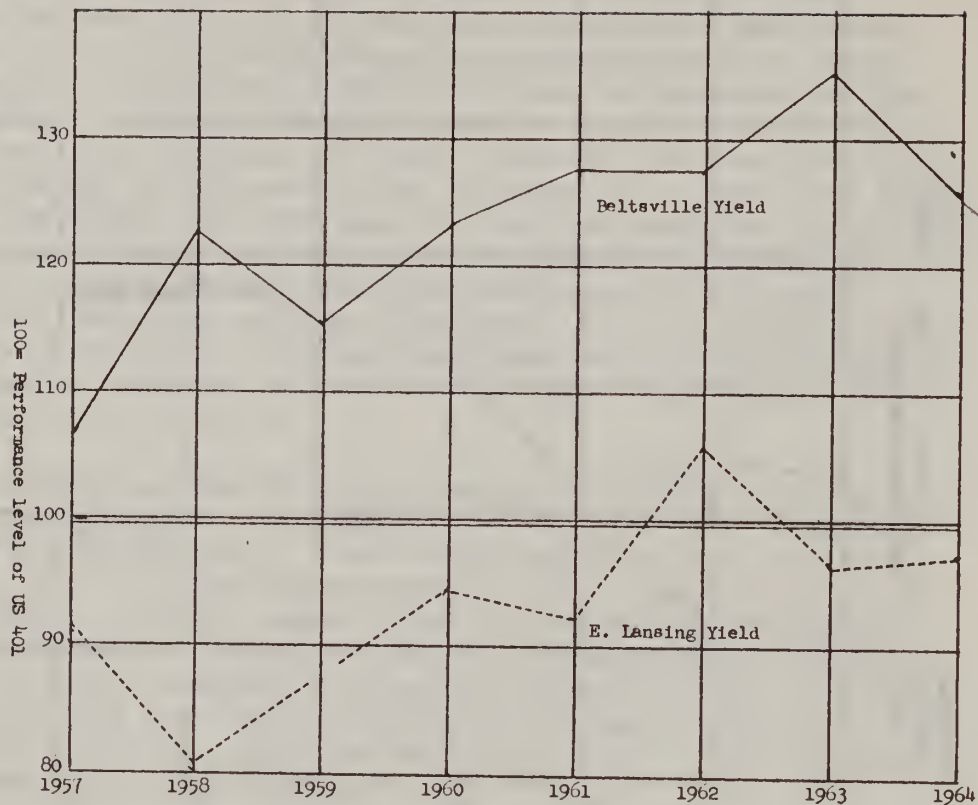
Graph 1. Disease resistance performance of multigerm breeding lines.



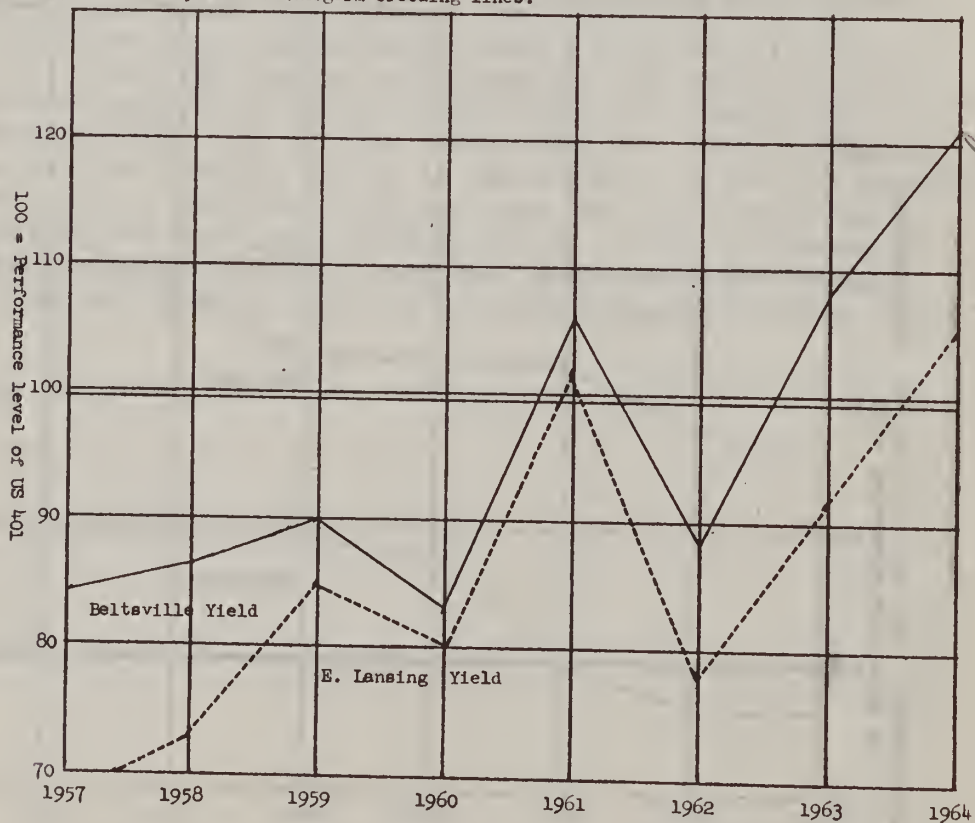
Graph 2. Disease resistance performance of monogerm breeding lines.



Graph 3. Root yield of multigerm breeding lines.

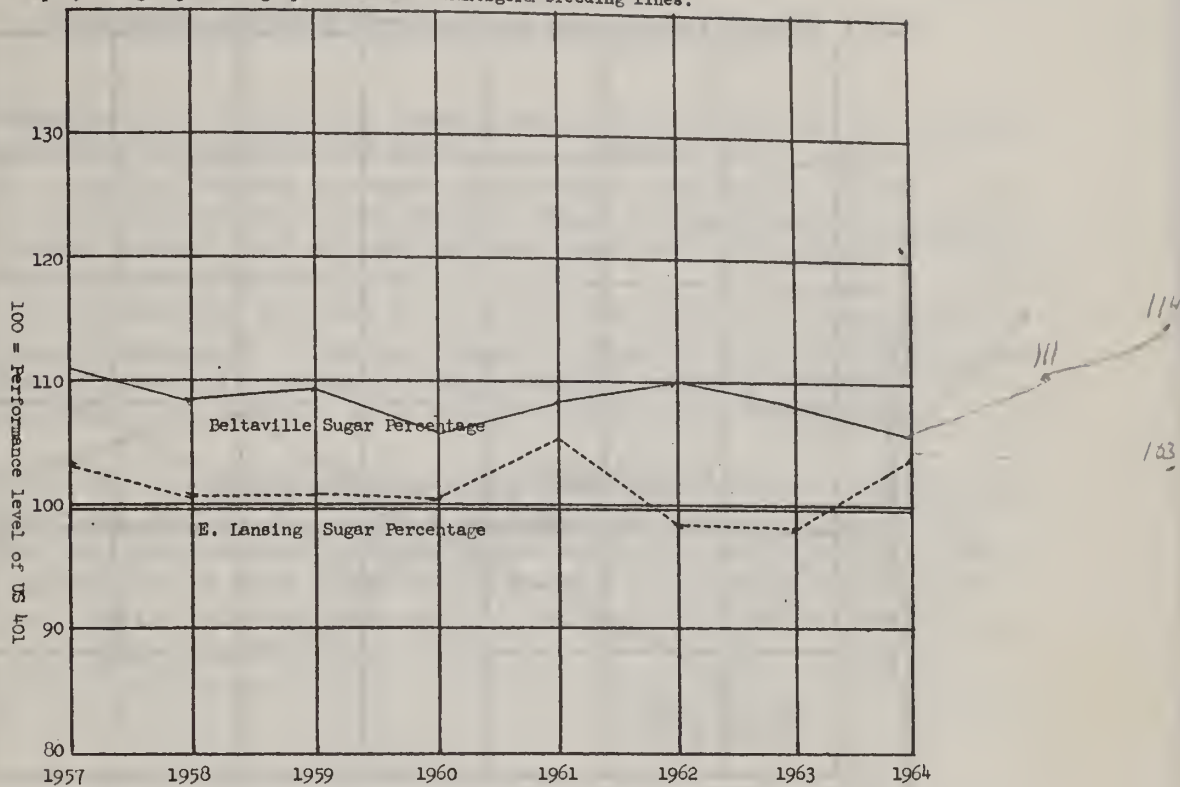


Graph 4. Root yield of monogerm breeding lines.

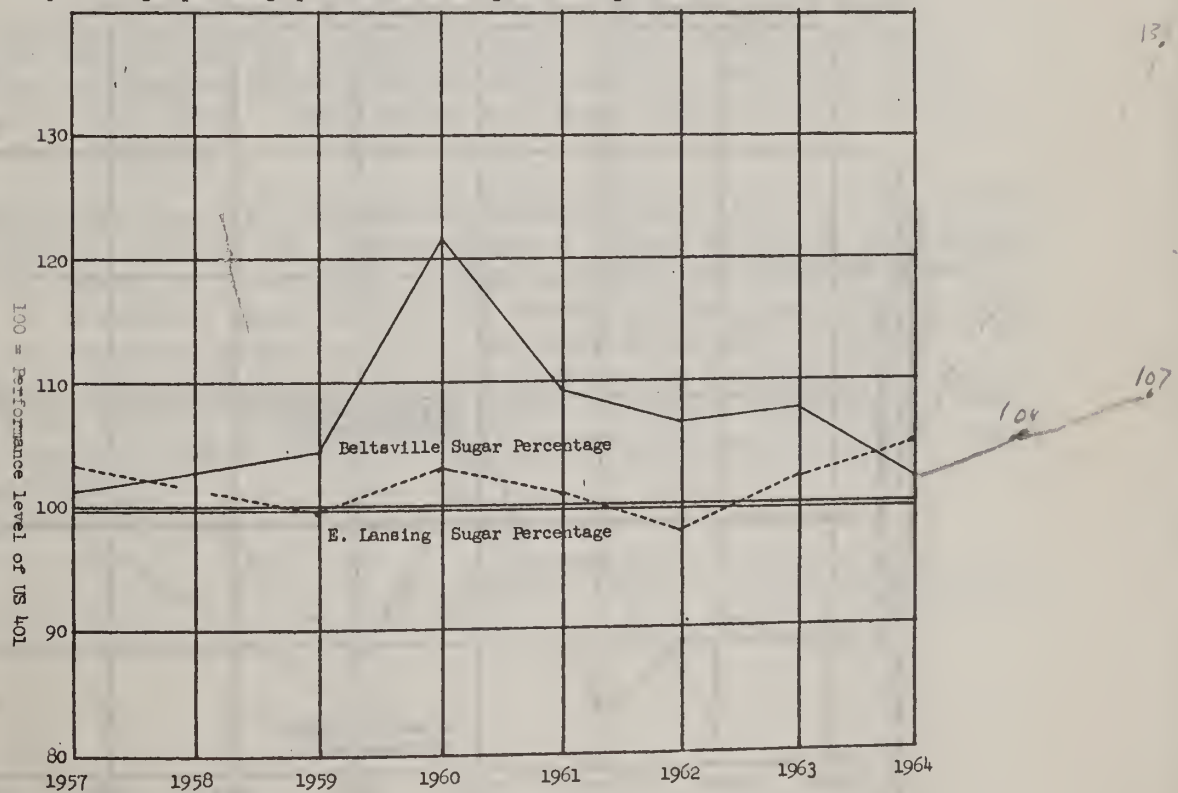


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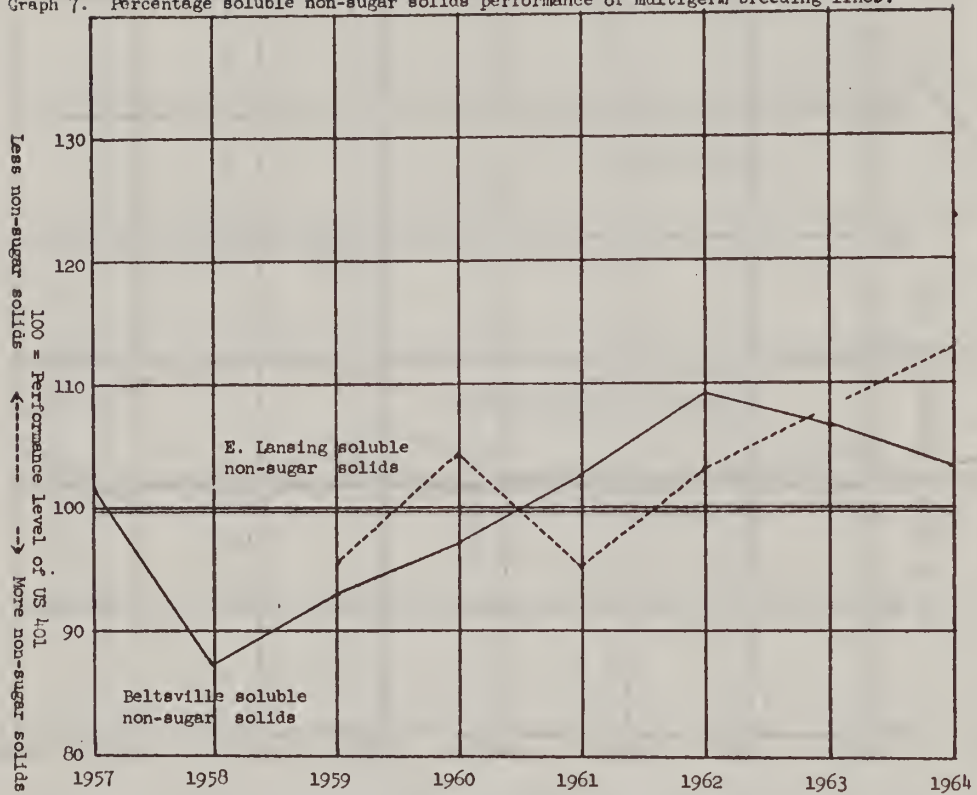
Graph 5. Sugar percentage performance of multigerm breeding lines.



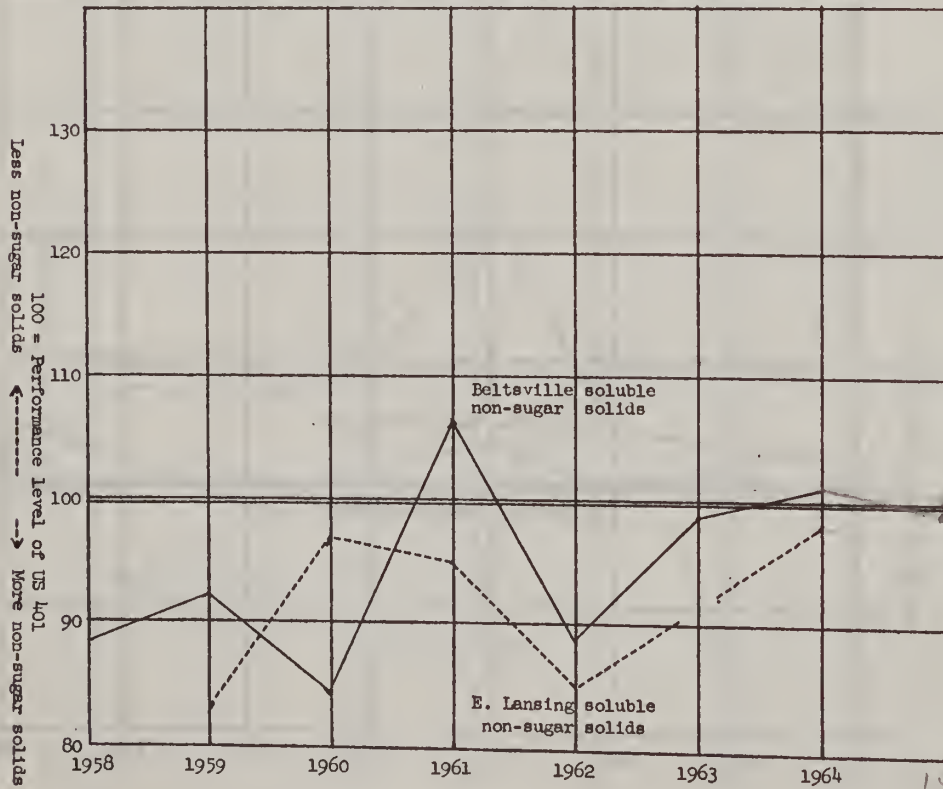
Graph 6. Sugar percentage performance of monogerm breeding lines.



Graph 7. Percentage soluble non-sugar solids performance of multigerm breeding lines.



Graph 8. Percentage soluble non-sugar solids performance of monogerm breeding lines.



Newly Developed Breeding Lines

The performance of SP 6322-0 in comparison with SP 5822-0 is of interest. Under Beltsville conditions, SP 6322-0 was slightly more resistant to leaf spot, slightly higher in sugar percentage, and better in yield. In two tests conducted by the Great Western Sugar Company in Ohio, SP 6322-0 also performed better than SP 5822-0 (see page 152, 1964 Report).

It is of interest that, for the first time, the purity of some of the open-pollinated monogerm lines was equal to that of good multigerm lines. Poor purity has been a problem in the monogerm breeding material, and continued efforts to improve this characteristic will be necessary.

In 1964, one new multigerm and two new monogerm O-types were found. The multigerm O-type should be valuable in improving the monogerm O-type lines. The two new monogerm O-type lines have more resistance to leaf spot and appear to be more vigorous than earlier monogerm O-types from Beltsville. Tests for combining ability will determine whether they might be of value commercially.

Experimental Hybrids in Observational Plots at Beltsville

Experimental hybrids in the screening trials in the Great Lakes area were planted in observational plots at Beltsville to determine their resistance to leaf spot. These plots also give some indication of yield potential and quality.

The data indicate that the two hybrids produced at Beltsville, SP 63399-01 and SP 63399-02, and all the open-pollinated lines, except SP 63624-0 and US 401, are better in resistance to leaf spot than the other experimental hybrids. As a result, under Beltsville conditions they were better yielding than the less resistant hybrids. The hybrids having tetraploid US 401 as pollinator generally had the least resistance to leaf spot. In some cases, hybrids with SP 5822-0 as male parent were more resistant to leaf spot than hybrids with SP 5460-0 as male parent; but in other cases, the reverse was true.

Leaf Spot Observational Plot

Conducted by: G. E. Coe

Location: Plant Industry Station, South Farm Plot F-11, Beltsville, Md.

Date of Planting: May 4, 1964

Date of Harvest: October 19, 1964

Experimental Design: Two 4-row observational plots

Size of Plots: 4 rows X 20' 24" apart

Harvested Area per plot for Root Yield: 4 rows X 20 feet

Samples for Sucrose Determinations: 2 samples from each plot--all the
beets in each of the two middle rows
taken as samples.

Stand Counts: Harvested beets counted when weighed

Recent Field History: 1961 - Rye - 400# 10-6-4 + 2% Boron, 2 tons limestone
1962 - Rye - 400# 10-6-4 + 2% Boron, 2 tons limestone
1963 - Beets - 250# 10-6-4 + 2% Boron, 2 tons "
150# N.

Fertilization of Beet Crop: 250# 10-6-4 + 2% Boron, 2 tons limestone

Black Root Exposure: Slight

Leaf Spot Exposure: Moderate

Other Diseases and Pests: None

Soil and Seasonal Conditions: Drought conditions developed in mid-August
and were terminated by irrigation on
August 24.

Reliability of test: Good for estimating leaf spot resistance.

Observational Plots

Year: 1964

Location: U.S.D.A. Nursery, Beltsville, Md.

Two 4-row plots.

(Results are the average of 2 plots)

Variety and Description	Acre-Yield							Beets Per 100'
	Gross							
	Sugar	Roots	Sucrose	Purity	Spot	Row		
	Pounds	Tons	Percent	Percent			Number	
SF 6322-0 MM	: 7054	: 26.52	: 13.30	: 78.5	: 1.50	:	77	
SF 63197-0 mm	: 6535	: 25.32	: 12.95	: 81.4	: 2.50	:	84	
SF 63196-0 mm	: 6282	: 24.83	: 12.65	: 78.1	: 2.75	:	88	
SF 63624-0 mm	: 6264	: 23.82	: 13.15	: 81.7	: 3.50	:	94	
SF 63399-02 mM Hybrid	: 6253	: 24.70	: 12.86	: 80.3	: 2.75	:	79	
SF 5822-0 MM	: 6236	: 24.55	: 12.70	: 78.3	: 1.88	:	90	
SF 63399-01 mM Hybrid	: 6187	: 25.78	: 12.00	: 77.9	: 2.75	:	79	
SF 63194-01 mm	: 5782	: 22.41	: 12.90	: 78.9	: 2.38	:	82	
(129 X 133) X SF 5460-0	: 5602	: 21.22	: 13.20	: 78.9	: 3.63	:	87	
US 401 MM	: 5457	: 23.42	: 11.65	: 76.6	: 3.63	:	90	
SL 126 X SF 5822-0	: 5291	: 20.62	: 12.83	: 79.2	: 3.25	:	91	
(128 x 129) x 133 X 5460-0	: 5271	: 20.35	: 12.95	: 77.4	: 3.00	:	71	
(129 x 133) X SF 5822-0	: 5103	: 20.20	: 12.63	: 77.6	: 3.50	:	82	
(128 x 129) x 133 X 5822-0	: 5098	: 20.07	: 12.70	: 78.7	: 4.00	:	72	
(127 x 128) X SF 5460-0	: 5054	: 19.47	: 12.98	: 79.4	: 3.50	:	81	
(126 x 128) X SF 5822-0	: 5044	: 20.42	: 12.35	: 76.9	: 3.63	:	89	
SL 126 X SF 5460-0	: 4927	: 19.63	: 12.55	: 76.1	: 3.50	:	91	
(126 x 128) X S P 5460-0	: 4922	: 19.80	: 12.43	: 77.7	: 4.00	:	74	
SL 126 X US 401 <u>4n</u>	: 4855	: 19.98	: 12.15	: 75.4	: 4.00	:	82	
F62-569 H3 X SF 5460-0	: 4851	: 20.33	: 11.93	: 75.6	: 3.25	:	82	
SL 122 X SF 5460-0	: 4808	: 19.95	: 12.05	: 76.3	: 4.25	:	86	
(127 x 128) X SF 5822-0	: 4793	: 19.05	: 12.58	: 77.9	: 4.00	:	76	
F62-569 H3 X US 401 <u>4n</u>	: 4594	: 19.50	: 11.78	: 77.6	: 4.13	:	90	
F62-569 H3 X SF 5822-0	: 4552	: 18.84	: 12.08	: 75.9	: 3.50	:	78	
(126 x 128) X US 401 <u>4n</u>	: 4469	: 18.65	: 11.98	: 75.1	: 4.25	:	77	
(129 x 133) X US 401 <u>4n</u>	: 4350	: 17.47	: 12.45	: 76.9	: 4.00	:	67	
62562H0 ms X SF 5822-0	: 4262	: 18.61	: 11.45	: 74.4	: 4.50	:	89	
(127 x 128) X US 401 <u>4n</u>	: 4026	: 18.25	: 11.03	: 75.8	: 4.38	:	76	

1966 Beltville Nursery Test

2m MM

	Pl. Wt.	U.S. 401	% of U.S. 401 Performance	Pl. Wt.	U.S. 401	% of U.S. 401 Performance
Expt 0	107.81	103.7	104	Expt. 1	104.8	81.6
Expt 10	115.0	103.2	111	Expt. 12	98.0	121.1
Expt 11	88.2	80.3	110	Total	202.8	202.7
Expt 13	108.6	101.8	107			182
Total	419.6	389.0	432			
			108			

av.

Leaf Spot

Leaf Spot

Expt. 0	8.818	14	137
" 10	9.363	16	141
" 11	9.576	16	140
" 13	7.375	14	147
Total			140

Expt. 1	9.576	14	132
" 12	10.182	15	132
av.			132

WT Total

% Sucrose

% Sucrose

Expt 0 (17)	12.25	1107	111
" 10 (14)	12.04	1053	114
" 11 (12)	12.45	1040	120
" 13 (10)	13.63	12.23	111
Total		445.6	114

Expt 1 (17)	11.95	1137	105
" 12 (9)	11.90	10.83	110
av.			107

% SNSS

% SNSS

Expt 0 (17)	2.701	2.76	102
" 10 (14)	2.931	3.26	110
" 11 (12)	2.786	3.01	107
" 13 (10)	2.973	3.11	104
av.			105

Expt. 1 (17)	2.881	3.07	106
" 12 (9)	3.309	3.61	108
av.			107

Blackroot Resistance

J.A.B.R. Rating (159)	13153	117
All progenies (522)	44605	115

(188) progenies - 16975	110
(573) " 53444	107

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Crops Research Division
Beltsville, Maryland 20705

To: Tobacco and Sugar Crops Staff
From: Thomas Theis, Chief *Thomas Theis*
Tobacco and Sugar Crops Research Branch
Subject: 1966 Combined Federal Campaign

Thank you for your generous contributions to the Combined Federal Campaign. The Division reached 112% of the projected goal, with 94% participation. This, of course, was achieved by your excellent cooperation in participating in this worthwhile cause.

